

LETTER OF TRANSMITTAL

TO: David Hoefer
U.S. Environmental Protection Agency, Region VII
901 North 5th Street
Kansas City, Kansas 66101

DATE: 8 February 2012
PROJ. NO. 890052.68
SUBJECT: Chemplex

WE ARE SENDING YOU THE FOLLOWING:

- Two CDs related to the Chemplex project, as requested by Nancy Swyers:
 - Chemplex – Technical Impracticability Evaluation Report Quarterly Report
 - Chemplex – Updated Focused Feasibility Study

REMARKS:

David—Please call with any questions.

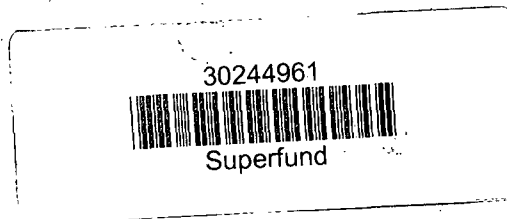
COPY TO:

Very truly yours,

ERLER & KALINOWSKI, INC.



C. David Umezaki, P.E.



*If enclosures are not as noted, please advise us
at once at (650) 578-1172.*



UPDATED FOCUSED FEASIBILITY STUDY

**Operable Unit No. 1 for Groundwater
Chemplex Site
Clinton, Iowa**

8 February 2012

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on behalf of ACC/GCC

Updated Focused Feasibility Study

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- Appendix B PME Plan Addendum 2, prepared by MWH Americas, Inc., dated 7 April 2011
- Appendix C *Technical Impracticability Evaluation Report*, prepared by MWH Americas, Inc., dated February 2012

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ACRONYMS AND ABBREVIATIONS

ACC/GCC	ACC Chemical Company and Getty Chemical Company
ARARs	Applicable or Relevant and Appropriate Requirements
BNA	base-neutral/acid
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAG	Community Advisory Group
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act, as amended
COC	chemical of concern
DAC	debutanized aromatic concentrate
1,2-DCE	1,2-dichloroethene
DNAPLs	Dense Non-Aqueous Phase Liquids
EKI	Erler & Kalinowski, Inc.
EPA	Environmental Protection Agency
Equistar	Equistar Chemicals
ESD	Explanation of Significant Differences
FFFS	Final Focused Feasibility Study, dated 20 July 2007 (EKI, 2007b)
HDPE	high-density polyethylene
IDNR	Iowa Department of Natural Resources
LDPE	low-density polyethylene
LGE	landfill gas extraction
Lyondell	Lyondell Chemical Company
MCL	maximum contaminant level
MWH	MWH Americas, Inc.
mg/L	milligrams per liter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OU-1	First Operable Unit
OU-2	Second Operable Unit
PAHs	polynuclear aromatic hydrocarbons
PCE	perchloroethene, also known as tetrachloroethylene or perchloroethylene
PCS Nitrogen	PCS Nitrogen Fertilizer, LP
PME Plan	Performance Monitoring Evaluation Plan (MWH, 2008a)
ROD	Record of Decision
Site	Chemplex Site
TBC	to be considered
TCE	trichloroethene (also known as trichloroethylene)
TI	Technical Impracticability

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ACRONYMS AND ABBREVIATIONS (continued)

ug/L	micrograms per liter
Updated FFS	Updated Focused Feasibility Study
VOCs	volatile organic compounds

1. INTRODUCTION

On behalf of ACC/GCC, Erler & Kalinowski, Inc. (“EKI”) has prepared this Updated Focused Feasibility Study (“Updated FFS”) for the Chemplex First Operable Unit for groundwater (“OU-1”). This Updated FFS has been prepared to revise the *Final Focused Feasibility Study, Operable Unit No. 1 for Groundwater, Chemplex Site, Clinton, Iowa* (“FFFS”, EKI, 2007b), previously submitted to EPA on 20 July 2007, based on additional monitoring data obtained over the past four years and the findings of the Performance Test of the exposure control remedy proposed in the 2007 FFFS. The Performance Test was performed from 2008 to the present. This Updated FFS also includes the updated Technical Impracticability Report.

The Chemplex OU-1 Record of Decision was issued in 1989 (EPA, 1989a). The OU-1 Consent Decree was entered in 1991 (EPA, 1989b), with the Remedial Design prepared in the early 1990s. The present groundwater pump-and-treat remedial system was constructed in 1994. Since that time, the knowledge of groundwater behavior at Chemplex has substantially increased, based on 17 years of monitoring data as well as experience at other sites with hydrogeology and contaminants similar to those found at the Chemplex Site.

This Updated FFS provides an updated analysis of approaches to managing chemically-impacted Chemplex Site groundwater that are protective of human health and the environment.

This Updated FFS consists of the following sections:

- Section 2: Site Background. Section 2 describes Site location and history, and summarizes remedial activities to date.
- Section 3: Site Characteristics. Section 3 discusses ACC/GCC’s current understanding of groundwater conditions at the Chemplex Site. In particular, the discussion focuses on managing groundwater impacted by Dense Non-Aqueous Phase Liquids (“DNAPLs”).
- Section 4: Development of Remedial Alternatives. Section 4 proposes updated groundwater remediation goals and Remedial Action Objectives. It also updates earlier discussions of Institutional Controls. Remedial alternatives are developed for evaluation in Section 5.
- Section 5: Comparative Analysis of Alternative. Section 5 evaluates the remedial alternatives against the nine evaluation criteria provided in the Comprehensive Environmental Response, Compensation and Liability Act and the National Oil and Hazardous Substances Pollution Contingency Plan (“NCP”).
- Section 6: References.

2. SITE BACKGROUND

2.1 Site Location

The Chemplex Site (“Site”) is located in Clinton County, Iowa in portions of Sections 19, 20, 29, and 30 within Township 81 North, Range 6 East. The Site, encompassing around 700 acres, is located approximately 1.5 miles northwest of the center of the City of Camanche and five miles west of the City of Clinton’s downtown, between U.S. Highway 30 and 21st Street (see Figure 2-1). The Site is located within the city limits of Clinton and Camanche. This area is predominantly semi-rural, with agricultural fields and scattered residences and some industries.

Industrial land uses are also present. The Chemplex polyethylene manufacturing plant is currently operated by Equistar Chemicals (“Equistar”), a subsidiary of LyondellBasell Industries (“Lyondell”). A former fertilizer manufacturing plant property, previously known as Hawkeye Chemical, Arcadian Fertilizers, and PCS Nitrogen Fertilizer, LP (PCS Nitrogen) and now owned by Cross Roads Land Development Corporation, is located southeast of the Chemplex Site. The Todtz Superfund Site is located about one mile to the south (see Figure 2-1).

Two streams, the Eastern and Western Un-named Tributaries, flow near the eastern and western boundaries of the Site. These two streams flow south, draining into Rock Creek. Rock Creek flows primarily west to east near the southern boundary of the PCS Nitrogen property. About one-and-one-half miles southeast of the Site, Rock Creek flows adjacent to a series of lakes that, in part, are the result of past quarrying operations. Rock Creek and the lakes eventually discharge to the Mississippi River, located about two miles south of the Site.

2.1.1 Site History

The polyethylene plant began operation in 1968. It manufactures both low-density polyethylene (“LDPE”) and high-density polyethylene (“HDPE”). The plant includes several ethylene production areas, water and wastewater treatment plants, a landfill, and several other chemical and product storage tanks and loading areas. LDPE beads and HDPE flakes are shipped from the plant in trucks and railroad cars.

A major byproduct of the polyethylene manufacturing process is debutanized aromatic concentrate (“DAC”), a liquid that is approximately 40 to 50 percent benzene. This byproduct is stored in aboveground tanks inside the plant before shipment via railroad car or tanker truck.

The West Region of the Site includes a seven-acre landfill that was used for the disposal of various materials, including demolition debris and water treatment sludges. From about 1968 to 1978, tetrachloroethylene, also known as perchloroethylene or PCE, was used from time to time to clean clogged piping (ENSR, 1990). Spent PCE was reportedly disposed within this landfill.

ACC/GCC operated the Chemplex facility from 1968 through 1984, after which it was sold to a series of owners. The polyethylene facilities are currently operated by Equistar. ACC/GCC owns the land occupied by the landfill, as well as other properties to the southwest.

2.1.2 Regulatory Agency Actions and Document Submittals

Table 2-1 summarizes key events and document submittals.

2.1.3 Description of the First Operable Unit (“OU-1”)

Based on remedial investigations completed in the late 1980s through the early 1990s, groundwater in portions of the Site was found to have been impacted by PCE, PCE’s daughter products, BTEX (benzene, toluene, ethylbenzene, and xylenes), and polynuclear aromatic hydrocarbons (“PAHs”).

The Record of Decision for the First Operable Unit (“the OU-1 ROD”) and subsequent project documents called for implementing a groundwater pump-and-treat recovery system (U.S. EPA, 1989a). The OU-1 ROD, issued by EPA on 27 September 1989, selected groundwater extraction and treatment for remediating impacted groundwater in the landfill and the DAC storage and truck loading area. The presence of PCE in the form of dense non-aqueous phase liquid (“DNAPL”) was not recognized at the time this initial ROD was issued.

After the presence of DNAPL was inferred from Site monitoring data, the ROD was modified by an Explanation of Significant Differences (“ESD”) issued by EPA on 26 July 1991, followed by a Consent Decree dated 7 November 1991 entered into between the United States and several potentially responsible parties (EPA, 1989b EPA 1991c).

In view of the limited effectiveness of available technologies to remediate DNAPL, EPA in its ESD focused on containing volatile organic compounds (“VOCs”) in groundwater. The ESD established a Point of Compliance boundary. For areas of chemical-containing groundwater located outside this Point of Compliance boundary, called the “Attainment Areas”, the ESD called for extracting and treating groundwater in an effort to meet health-based cleanup standards for groundwater. For the area within the Point of Compliance boundary, the objective, if practicable, was removal and containment of chemical mass until these areas would no longer act as a source of groundwater contamination to the Attainment Areas.

The ESD allowed for implementing different approaches to groundwater remediation if it were demonstrated that groundwater extraction and treatment could not restore groundwater to drinking water standards outside the designated Point of Compliance boundary.

The Chemplex groundwater recovery system was constructed in 1994 and became operational in late 1994. The system consists of 50 extraction wells that are screened at various depths in the soil overburden and underlying bedrock layers. When the recovery system is in operation, extracted groundwater is conveyed to the Chemplex groundwater treatment system in two streams. One stream, which was anticipated to contain both PAHs and VOCs, is termed the

base-neutral/acid (“BNA”) Stream¹. The other stream, anticipated to contain only VOCs, is referred to as the VOC Stream. The BNA and VOC streams are passed through separate air strippers to remove VOCs. The BNA stream also flows through granular activated carbon to remove PAHs. After treatment, the streams are combined and discharged to the Mississippi River through a permitted outfall shared with the neighboring Equistar polyethylene plant.

As discussed in greater detail in Section 4.1, the groundwater recovery and treatment system was placed into standby mode on 29 September 2008 as part of the EPA-approved Performance Test of the “Exposure Control” alternative described in the FFFS. Cumulatively, approximately 28,000 pounds of VOCs were removed by the groundwater recovery and treatment system as of 29 September 2008 (see Table 3-1).

2.1.4 Description of the Second Operable Unit (“OU-2”)

The Second Operable Unit, also called “OU-2,” focused on remediating impacted soil. OU-2 remedial actions included constructing a low-permeability cover over the Chemplex landfill and performing landfill gas extraction (“LGE”) to reduce VOC mass remaining in the landfill material. The ROD for OU-2 issued by EPA on 12 May 1993 (EPA, 1993a) states that the Remedial Action Objectives for these measures were “to eliminate direct contact threats posed by the contaminated soils and wastes and reduce contaminant migration from soils and wastes to groundwater.” EPA and the potentially responsible parties entered into a Consent Decree for OU-2 in 1995 (EPA, 1995).

The OU-2 Statement of Work established cleanup requirements for the soil remedy. To eliminate threats of direct contact, several areas within the polyethylene plant were designated for construction of caps or vegetative covers and posting of warning signs. These caps and covers have been constructed and are inspected annually and repaired as needed.

To reduce contaminant migration from soil and landfilled waste to groundwater, the OU-2 Statement of Work also called for operation of a LGE system for the unsaturated zone at the Chemplex Landfill, located in the northwestern portion of the Site. Five compounds, namely PCE and the BTEX compounds, were designated as “Target Compounds”. As described in the Statement of Work, the Landfill Gas Extraction system was to operate either until the Target Compound concentrations dropped in the extracted vapor to certain prescribed levels, or until four years of cumulative operation were recorded for each active LGE well.

The low-permeability cover and LGE system were constructed in 1997. Details of the cover are described in the construction completion report prepared by Golder Associates (1998).

The LGE system operated from February 1998 to April 2003. The system consisted of 55 LGE wells, a collection system for recovering floating product, and a catalytic oxidizer for treating the VOC-containing vapor stream from the LGE wells. The LGE system was permanently shut down once four years of cumulative operation was achieved for all active LGE wells. VOC recovery from the LGE system decreased over time and, at the time the

¹ Base-neutral/acid refers to a type of analytical test used to detect PAHs.

system was shut down, had reached low-rate, asymptotic conditions. Cumulatively, based on vapor flowrates and sample analyses, approximately 53,100 pounds of VOCs were removed by the LGE system, including approximately 32,700 pounds of the five designated Target Compounds. ACC/GCC continues to maintain the OU-2 Study Areas and the low-permeability landfill cover.

3. SITE CHARACTERISTICS

This section of the Updated FFS discusses ACC/GCC's current understanding of the Chemplex Site. As described in this section, there have been several advances in the understanding of Site conditions since the pump-and-treat remedy was implemented in the mid-1990s. This increased knowledge has prompted ACC/GCC to reevaluate the groundwater remedy and look for more effective ways to protect human health and the environment.

3.1 Site Geology

A schematic illustration of the Chemplex Site stratigraphy is presented on Figure 3-1. The stratigraphic layers at Chemplex, from the ground surface downward, consist of (1) an alluvial, unconsolidated soil overburden, (2) several fractured Silurian-era dolomite layers, consisting of the Upper Scotch Grove, Lower Scotch Grove, Picture Rock, Farmers Creek, Lower Hopkinton, and Blanding layers, and (3) the Ordovician-era Maquoketa Shale layer.

The massive, dense shales of the Maquoketa Formation have extremely low permeability and are believed to act as an aquiclude, essentially restricting all flow. The Picture Rock layer, which has a lower permeability than the overlying and underlying bedrock layers, restricts groundwater flow but does not block such flow completely.

3.2 Site Hydrogeology

Groundwater occurs at the Site within both the soil overburden and the underlying bedrock layers. The bedrock water-bearing zones are usually confined, with the groundwater potentiometric surface typically situated within the overburden. In general, groundwater flows laterally from north to south at the Chemplex Site in conformance with area topography, with higher gradients seen in the areas near the Eastern and Western Un-Named Tributaries.

In addition to these lateral gradients, groundwater gradients can also exist in a vertical direction. Vertical gradients in the downward direction have been observed in the East Region of the Site. Such gradients, which appear to be natural, are measured in the East Region both (1) across the Picture Rock layer and (2) between the dolomitic bedrock layers, namely the Farmers Creek, Lower Hopkinton, and Blanding, that underlie the Picture Rock and overlie the Maquoketa Shale. In contrast, vertical gradients in the West Region are near-neutral.

A confined aquifer, also known as a "pressure aquifer", is one bounded above and below by impervious formations. The dolomite bedrock aquifers at the Chemplex Site generally are confined by the Overburden, which is a layer of clay and silt with interfingering local sandy channel deposits. The Picture Rock Formation is a bedrock unit of low permeability that appears to provide a partial confining layer for the underlying Farmers Creek unit.

The presence of confining layers at the Chemplex Site is believed to slow the vertical flow of chemicals of concern in downgradient areas. For example, the Picture Rock layer is considered to restrict movement of groundwater from the Farmers Creek unit to Rock Creek, despite a probable upward gradient in the vicinity of the creek.

Figures 3-2 through 3-4 show the estimated groundwater potentiometric surfaces in April 2008 for the three main bedrock layers of concern, namely the Upper Scotch Grove, Lower Scotch Grove, and Farmers Creek layers. Most of the dissolved contaminant mass is located in the Upper Scotch Grove and Lower Scotch Grove Formation, with PCE also found in the Farmers Creek unit.

While chemicals of concern have been detected in the Farmers Creek and Lower Hopkinton layers underlying the Picture Rock, ACC/GCC suspended active extraction of groundwater from the Lower Hopkinton in 1999 and the Farmers Creek in 2005 with EPA's approval in order to avoid increasing the naturally-downward vertical gradients that can pull contaminant mass to lower layers.

Although Figures 3-2 and 3-3 suggest capture of groundwater by the Chemplex groundwater recovery system in the upper bedrock layers, the chemical monitoring data collected from these layers indicated that a portion of the contaminant mass in the dissolved plumes was eluding capture. This unrecovered VOC mass crossed the current Point of Compliance boundary, particularly in the East Region of the Site.

As discussed in greater detail in Section 4.1.2, the groundwater recovery and treatment system was placed into standby mode on 29 September 2008 as part of the EPA-approved Performance Test of the "Exposure Control" alternative described in the FFFS. Figures 3-5 through 3-7 show the estimated groundwater potentiometric surfaces in May 2010, approximately 20 months after the suspension of groundwater extraction. Based on a comparison between the May 2010 potentiometric surface maps and the April 2008 potentiometric surface maps, the horizontal groundwater gradient has flattened due to the cessation of groundwater extraction. As discussed in Section 4.1.2.2, by reducing lateral flow velocities, this flattening of the gradient is believed to allow more time for natural degradation processes to reduce PCE concentrations.

3.3 Site Chemicals of Concern

The primary chemical of concern ("COC") at the Chemplex Site is PCE. PCE was used during the early period of polyethylene plant operation, from about 1968 through 1978. During this period, hot PCE was circulated through process equipment and piping from time to time to unclog partially-solidified plastic that accumulated inside the equipment during polyethylene manufacturing. The resulting PCE and plastic mixture was disposed in the Site landfill.

The other COCs in Site groundwater are benzene, derived from DAC, and PAHs. Polyethylene manufacturing begins with the production of ethylene feedstock from natural gas liquids. DAC, which consists largely of benzene and other aromatic organic compounds, is formed during ethylene production and sold as a byproduct for use off-site. The DAC

Storage Tank at the polyethylene plant reportedly had leaks during the 1980s. PAHs are also formed during the polyethylene manufacturing process.

Although the Chemplex landfill is the primary source of PCE to groundwater, there is believed to be a possible second source of PCE, located within the East Region of the Site. While the landfill contains both PCE and DAC, the East Region source contains PCE but no DAC. This second source, which could not be identified during the Remedial Investigations, is believed to be smaller than the landfill source (Montgomery Watson, 1992). These two sources have given rise to two separate PCE plumes, called the “West Plume” and the “East Plume”.

PCE and its breakdown products are the main COCs at the Site. These chlorinated compounds are sometimes resistant to breakdown, although they can be degraded by biological action (“biodegraded”) under the right conditions. The aromatic organics in DAC do not appear to be migrating far from the landfill or the DAC storage area, because these compounds, including benzene, are easily biodegraded. PAHs are poorly mobile in soil and groundwater and typically do not migrate in groundwater.

The distribution of PCE in the overburden, Upper Scotch Grove, Lower Scotch Grove, Farmers Creek, Lower Hopkinton, and Blanding layers is presented on Figures 3-8 through 3-13. As shown within the data boxes posted on Figures 3-9 through 3-11, PCE had already migrated beyond the Point of Compliance boundary in several stratigraphic layers before the groundwater extraction system was turned on in late 1994. This migration beyond the Point of Compliance boundary was acknowledged by EPA’s 1991 Explanation of Significant Differences (EPA, 1991c). The ESD put forth the objective of pulling back this PCE using the groundwater recovery system in an effort to achieve cleanup goals within the Attainment Area.

Analyses performed in 2007 and 2008 concluded that (1) a significant portion of the PCE in groundwater in the downgradient Site area was not being recovered, and (2) since recovery system startup, the horizontal extent of the plume had generally not diminished, and PCE mass in the lower stratigraphic layers had increased in places. Evidence for this conclusion included the following:

Downgradient PCE concentration contours had not improved since startup of the groundwater recovery system in 1994. Figure 3-15 shows the PCE concentration contour at the 5 micrograms per liter (“ug/L”) concentration for the Lower Scotch Grove bedrock layer, which is present in both the upgradient and downgradient Site areas. The contour is shown for 1992 (pre-pumping) data; the 2008 data collected prior to the suspension of groundwater extraction; and the 2011 data collected approximately three years after groundwater extraction was suspended. The 2008 and 2011 PCE contours have advanced downgradient (southward) compared with the earlier, pre-pumping contour based on 1992 data, particularly in the area southeast of the current Point of Compliance boundary.

PCE concentrations in groundwater monitoring wells had not shown a consistent downward trend. Figures 3-8 through 3-14 present a time series of PCE concentrations in each monitoring well, from before the start of groundwater recovery through Fall 2010. In 2008, to evaluate concentration trends under the active pump-and-treat remedy, ACC/GCC performed a Mann-Kendall statistical test (see Table 5 of EKI, 2008a). For this evaluation each time series was evaluated to determine if there is a statistically-significant upward or downward trend. The following table summarizes this evaluation for each stratigraphic layer, with the shallowest layers shown first:

Stratigraphic Layer	Wells with PCE Downtrend	Wells with No Trend	Wells with PCE Uptrend
Overburden	2	5	0
Upper Scotch Grove	1	10	0
Lower Scotch Grove	6	5	9
Farmers Creek	1	8	2
Lower Hopkinton	0	5	0
Blanding	0	2	1

As of 2008, concentrations had been lowered in certain Site areas and layers, but there was no consistent downward trend in PCE concentrations observed.

PCE concentrations in deeper monitoring wells had often increased. While most of the residual PCE mass is believed to be within the Upper Scotch Grove bedrock layer, PCE concentrations often increased in deeper layers. As shown in the above table, PCE concentrations increased, particularly in the Lower Scotch Grove and Farmers Creek strata. Even after the suspension of extraction from the Farmers Creek extraction wells in 2005, the groundwater extraction system was unable to reverse the naturally-downward vertical gradients in certain Site areas that pull PCE mass downward into lower zones, where the PCE cannot be effectively recovered.

As discussed below in Section 3.4.3 impacted groundwater has been migrating past the Point of Compliance due to fractures present in the dolomite bedrock. These fractures, which exist both horizontally and vertically, are partially interconnected, potentially providing a flow path for migrating groundwater. As discussed below in Sections 3.4.2 and 3.4.3, dead-end or narrow fractures likely also provide a collection point for source chemicals.

It is believed that the extraction system affected the movement of PCE-containing groundwater in these downgradient areas. In particular, the cones of depression created by the extraction wells may have affected the PCE migration at the Chemplex Site in several ways. First, PCE-containing groundwater can be moved laterally, such that PCE is found in areas where it was not encountered before. Second, vertical migration, either upward or downward, may be induced between layers. Third, groundwater extraction wells draw in clean groundwater from outside the plume, further affecting PCE levels. This clean water contains dissolved oxygen, which can inhibit the microbial reductive dehalogenation of PCE, an anaerobic (non-oxygen) process that serves to break down PCE biologically.

As a result of these findings, the groundwater recovery and treatment system was placed into standby operation on 29 September 2008 as part of an EPA-approved Performance Test of the “Exposure Control” alternative described in the FFFS. The PCE concentrations in wells sampled during the Performance Test are shown on Figures 3-8 through 3-13. These figures represent PCE concentrations visually on an order-of magnitude basis with colored dots and colored rings.

These figures show that 66 out of the 72 wells sampled during both 2008 and 2010 had PCE concentrations in 2010 that were of the same order-of-magnitude as they were prior to the Performance Test. Three wells showed order-of-magnitude PCE decreases and three wells showed order-of-magnitude PCE increases. Figure 3-15, which shows the PCE plume over time, indicates in graphic form that the lateral extent of the PCE plume remained largely stable during the Performance Test. The concentrations of other VOCs generally followed a similar pattern, with TCE, cis-1,2-DCE and vinyl chloride concentrations generally remaining of the same order of magnitude over the Performance Test period.²

3.4 Characteristics and Presence of Dense Non-Aqueous Phase Liquid (“DNAPL”)

3.4.1 Characteristics of DNAPL

Dense non-aqueous phase liquids (“DNAPLs”) are chemical compounds that are heavier than water (“dense”), are only slightly soluble in water (“non-aqueous”), and can form a separate layer (“phase”) when in contact with water. DNAPLs, due to their density and low solubility, can migrate to significant depths below the water table in overburden and bedrock under the influence of gravity and site stratigraphy. DNAPL will migrate along multiple pathways, both vertically and laterally, in a manner that is sometimes referred to as “dendritic” due to its resemblance to the branches of a tree. PCE in its pure form is a DNAPL. The presence of DNAPL at the Chemplex Site is discussed in Section 3.4.2.

Within the overburden, the specific migration pathways of DNAPL are governed by the bedding (layering) structure of the unconsolidated overburden material (Kueper et al., 2003). DNAPL in the overburden can come to rest in pools above finer-grained horizons within the overburden, or can distribute itself in disconnected blobs and ganglia of DNAPL formed at the trailing end of a migrating DNAPL mass (“residual DNAPL”). Residual DNAPL and DNAPL pools can be found in both unsaturated and saturated overburden and bedrock and are held in place by capillary forces.

Within the bedrock, DNAPL can enter open bedrock fractures if the capillary entry pressure exceeds the fracture entry pressure (Lipson et al., 2005). Essentially, this means that DNAPL can enter bedrock fractures if the downward forces are greater than the upward forces. The downward forces are related to the height (thickness) and density of the DNAPL above the fracture and the upward forces are determined by the fracture size (called the “radius”) as well

² Of the 72 total wells, 65 wells had stable TCE concentrations, 60 wells had stable cis-1,2-DCE concentrations, and 67 wells had stable vinyl chloride concentrations, where “stable” is defined as having the same order-of-magnitude concentration in 2008 and 2010.

as interfacial tension and contact angle, which describe the physical relationships between the DNAPL, groundwater, and bedrock. As in the overburden, DNAPL can distribute itself in fractured bedrock as residual DNAPL (that is, disconnected blobs and ganglia of DNAPL liquid formed at the trailing end of a migrating DNAPL mass, such as within dead end fractures) and in continuous distributions (“pools”) usually associated with horizontal, low permeability bedrock features.

It is likely that after DNAPL enters a fracture network, it continues its downward and lateral migration until the DNAPL source is dissipated into the fracture network and absorbed by the surrounding rock pores (Great Britain Environment Agency, 2003). The DNAPL absorbed in these rock pores, however, can dissolve into groundwater and thus be an ongoing contamination source.

Residual and pooled DNAPL in the overburden and bedrock will dissolve into flowing groundwater to give rise to “dissolved phase” plumes. These dissolved phase plumes are then subjected to processes such as advection, dispersion, sorption, matrix diffusion, and degradation. These processes are described below (adapted from EPA, 1998):

Summary of Key Processes Affecting Solute Fate and Transport

Process	Description	Dependencies	Effect
Advection	Movement of solute by bulk groundwater movement.	Dependent on aquifer properties, mainly hydraulic conductivity, porosity, and hydraulic gradient.	Main mechanism driving contaminant movement in the subsurface.
Dispersion	Fluid mixing due to groundwater movement and aquifer heterogeneities.	Dependent on aquifer properties and scale of observation. Independent of contaminant properties.	Causes longitudinal, transverse, and vertical spreading of the plume. Reduces solute levels.
Diffusion	Spreading and dilution of contaminant due to molecular diffusion.	Dependent on contaminant properties and concentration gradients.	Diffusion of contaminant from areas of higher concentration to areas of lower concentration.
Sorption	Reaction between aquifer rock and solute, whereby organic compounds sorb to organic carbon or clay minerals.	Dependent on aquifer matrix properties (organic carbon and clay mineral content, bulk density, specific surface area, and porosity) and contaminant properties.	Tends to reduce apparent solute transport velocity and remove solutes from the groundwater by means of sorption to the aquifer matrix.
Recharge (Simple Dilution)	Movement of water across the water table into the saturated zone.	Dependent on aquifer matrix properties, depth to groundwater, surface water interactions, and climate.	Dilutes the contaminant plume. May replenish electron acceptor concentrations, especially dissolved oxygen.
Volatilization	Volatilization of dissolved contaminants into the vapor phase.	Dependent on the chemical's vapor pressure and Henry's Law constant.	Removes contaminant from groundwater and transfers mass to soil gas.
Biodegradation	Microbial reactions that degrade contaminants.	Dependent on groundwater geochemistry, microbe population, and contaminant. Can occur under aerobic or anaerobic conditions.	May result in complete degradation of contaminants. Often the most important process to reduce chemical mass.
Abiotic Degradation	Chemical transformations that degrade chlorinated solvent contaminants without microbes.	Dependent on contaminant properties and groundwater geochemistry.	Can result in partial or complete degradation of contaminants. Rates typically much slower than for biodegradation.
Partitioning from DNAPL back into the dissolved phase ("back- diffusion")	DNAPL, either residual or diffused into rock pores, tends to act as a continuing source of groundwater contamination.	Dependent on aquifer matrix and contaminant properties, as well as groundwater movement near source areas.	Dissolution of contaminant from DNAPL represents the primary source of dissolved contamination in groundwater.

Groundwater flow in fractured bedrock is through the bedrock matrix (pores) and bedrock fractures. Flowrates through bedrock fractures are significantly greater than through the bedrock matrix due to the bedrock fractures having higher permeability than the matrix pores. Flow through the bedrock matrix is more predictable, however, than flow through fractures due to variations in fracture width, degree of interconnection, and orientation.

3.4.2 Presence of DNAPL

As described earlier, spent PCE used to unclog process piping during polyethylene manufacturing was reportedly disposed in the landfill, where it became the major source of PCE contamination at the Site. After traveling through the overburden, PCE in the form of

DNAPL is believed to have migrated vertically and horizontally until such time as it became immobile, due to being absorbed (“sorption”) or after being trapped in dead-end fractures (see Section 3.2). Residual DNAPL likely remained along the travel routes within the soil overburden and the fractures of the Scotch Grove Formation. The top of the Scotch Grove Formation, which varies in elevation, is approximately 5 to 50 feet below ground surface. The entire formation, including both the Upper Scotch Grove and Lower Scotch Grove units, is about 100 feet thick. The total area of the two PCE plumes at Chemplex, the West Plume and East Plume, exceeds 200 acres and extends locally to a depth of up to about 150 feet.

Residual DNAPL may diffuse or dissolve into migrating groundwater. Feenstra et al. (1996) report that DNAPL, such as that derived from PCE solvent, may completely diffuse into unconsolidated clay and silt within days or weeks, and into the pores of sedimentary rock within months to years. PCE-containing groundwater can then move through rock pores, or can travel along the fracture network present in this dolomite bedrock. More PCE mass is likely found in the rock pores, but PCE may migrate faster via fractures than it does through pores. PCE may also be held (“sorbed”) by organic carbon found in bedrock and overburden.

PCE in the form of DNAPL has not been directly observed in the soil or groundwater at the Chemplex Site, but the presence of DNAPL has been inferred from PCE concentrations measured in groundwater. PCE concentrations in West Region groundwater have been measured as high as 95,000 ug/L, which corresponds to about 60 percent of PCE’s maximum solubility in water. Concentrations greater than a few percent of maximum solubility are considered indicative of DNAPL presence in the vicinity. PCE concentrations in East Region groundwater have been measured as high as 3,800 ug/L, corresponding to about 2.5 percent of PCE’s maximum solubility, suggesting the presence of DNAPL. It is unknown what portion of DNAPL, if any, is residual and what is pooled, as there is no reliable means of ascertaining this information without potentially disturbing its equilibrium. Characterizing DNAPL source areas carries the risk of remobilizing DNAPL and allowing it to migrate deeper into the subsurface.

Whether or not PCE still exists in the form of DNAPL, most of the remaining PCE mass will now be found in bedrock pores and thus will be available for back-diffusion for many decades.

3.4.3 Implications of the Presence of DNAPL and Dissolved VOCs in Fractured Bedrock

Reliable containment and remediation of contaminated groundwater in fractured rock is not possible for the following reasons noted by the National Research Council (1994):

Predicting contaminant movement in fractured rock is extremely complex because contaminants will move along the line of least resistance, which is the fracture and often in a direction that cannot be determined by conventional methods for hydrogeologic investigations. Because of the tendency of contaminants to move through the fractures to locations that are difficult to determine and access, remediation of fractured rock aquifers poses an extreme technical challenge.

Ten years later, a review of DNAPL treatment technologies by the Interstate Technology Research Council (2004) indicated that the technical challenges of remediating DNAPL in fractured bedrock still remained:

In general, coarse grained unconsolidated media are easier to treat and monitor than fine-grained or highly heterogeneous material. DNAPL contamination in clay and fractured bedrock is even more difficult...Complex hydrogeologic settings (e.g., tight soils, fractured bedrock, karst) represent significant technical challenges and increased costs for treatment design, implementation, and performance assessment, [and] the fundamental technical difficulties of cost-effectively treating DNAPL sources in complex settings remain a largely unresolved problem.

Due to the inability of extraction to capture groundwater from the entirety of the bedrock's fracture network, the Chemplex recovery system has not been able to fully contain groundwater impacted by volatile organic compounds ("VOCs"), including PCE. Due to this fracturing, the hydraulic capture of the Chemplex recovery system cannot be significantly improved and made reliable by constructing additional extraction wells. The specific bedrock fractures that would need to be intercepted or influenced by the groundwater recovery wells to reliably control VOC migration cannot be identified with currently-existing technologies.

As shown in Table 3-1, the rate of VOC mass removal progressively declined following groundwater recovery system startup in 1994, and as of 2007-2008 had reached a steady level of about two pounds per day. This decline suggests groundwater extraction removed the more-concentrated PCE from permeable sand and gravel areas in the overburden, and perhaps also from some of the larger bedrock fractures. Although significant VOC mass was removed prior to the Performance Test, pre-test flowrates indicate the Chemplex groundwater recovery system is likely now limited to removing PCE that is diffusing back out of the bedrock matrix and into groundwater migrating through nearby fractures.

The ramification of such diffusion for the Chemplex Site is that significant PCE mass will persist along the former DNAPL migration pathways long after the blobs and drops of residual DNAPL have largely disappeared. PCE will then "back-diffuse" out of the impacted clay, silt, and bedrock into migrating groundwater. As an example, D.A. Reynolds and B.H. Kueper (2002) modeled the migration of PCE DNAPL through a single fracture in a clay aquitard. They found that while the residual DNAPL disappeared in about 21 weeks, PCE in groundwater, at concentrations exceeding the maximum contaminant limit ("MCL") for drinking water, was predicted to persist for over 1,200 years due to this back-diffusion process.

This observed mass transfer limitation means that long-term removal of PCE mass will not be controlled by how fast groundwater is pumped, but instead by the rate at which PCE back-diffuses from the impacted silt, clay, and dolomite. Thus, additional groundwater extraction will not appreciably accelerate the timeframe for site

remediation by mass removal. This effect will be most pronounced in the East Plume, where the potential for PCE mass destruction by biodegradation is limited as was explained in Appendices A and B of the FFFS.

The distribution of DNAPL or other residual PCE sources in the subsurface is extremely difficult to characterize. Similar to many other fractured bedrock sites, DNAPL has never been directly observed in soil cores or groundwater monitoring wells at the Chemplex Site. The difficulty in locating the DNAPL is a major obstacle to source remediation at Chemplex. There is no reliable means of identifying or locating DNAPL that may remain. Even if DNAPL could be located, there is concern that aggressively looking for it, or attempting to remediate it, could promote mobilization of residual material. The increased mobilization of contamination has been shown with the pump and treat system which operated from 1994 through 2008.

The presence of residual DNAPL in fractured bedrock also eliminates the potential for reliable VOC plume remediation by controlling remaining source areas. Even if all residual DNAPL at the Chemplex Site source areas could somehow be identified and completely destroyed, most of the remaining PCE mass is likely now located in rock pores. This remaining mass will continue to diffuse back out of the impacted fractured rock into migrating groundwater.

3.5 Intrinsic Bioremediation

Biological transformation of VOCs by indigenous bacteria can occur under aerobic conditions (that is, in the presence of oxygen) or under anaerobic (lack of oxygen) conditions. Aerobic degradation of chlorinated VOCs entails direct or indirect (“cometabolic”) oxidation to carbon dioxide, water, and chloride. PCE, which does not degrade aerobically, is typically degraded under anaerobic conditions via a process called reductive dehalogenation or reductive dechlorination.

An investigation performed by EKI in 1997 and 1998 (EKI, 1998) established that anaerobic reductive dechlorination is transforming PCE in groundwater in the upper bedrock layers in the Site’s West Region. In this western area, hydrocarbons emanating from the Landfill serve as an energy source, called “electron donor,” for bacterial activity. This electron donor was found to be available in West Region groundwater in sufficient quantity such that microorganisms are completely dechlorinating PCE to create the non-chlorinated daughter products ethene and ethane.

Levels of available electron donor are lower in East Region groundwater. The presence of nitrate in East Region groundwater, released from part fertilizer manufacturing, also may limit reductive dehalogenation, as nitrate can compete with PCE as a bacterial “electron acceptor.” Bacterial activity is apparently still occurring in East Region groundwater as evidenced by the presence of trichloroethene (“TCE”), cis-1,2-dichloroethene (“cis-1,2-DCE”), ethene, and ethane, which are biological transformation products, also called “daughter products,” resulting from the anaerobic reductive dechlorination of PCE (EKI, 1998).

To augment ongoing biological transformation processes, in the Summer of 2009 ACC/GCC pilot tested the treatment of localized “hot spots” of PCE in groundwater at the Site. The pilot test applied permanganate, a strong oxidant, at one well and vegetable oil, a source of supplemental electron donor to promote biological breakdown of PCE, at five wells. The results of this successful pilot test are discussed in Section 4.1.2.

3.6 Degradation of Groundwater Quality Caused by Nitrate and Ammonia Nitrogen Releases

Downgradient of the southeast boundary of the Chemplex Site is a former fertilizer manufacturing plant. Constructed in the 1960s, the plant produced anhydrous ammonia, ammonium nitrate, and urea nitrogenous fertilizers until 2000, when operations were discontinued and the manufacturing equipment was dismantled. Past releases of nitrogenous compounds have resulted in substantial ammonia and nitrate concentrations under and downgradient of the former fertilizer facility. Nitrogenous compounds have migrated to the Scotch Grove, Farmers Creek, and Lower Hopkinton bedrock layers.

As shown on Figure 3-15, the East Region VOC plume is flowing in groundwater through bedrock in a generally south or southeast direction, potentially toward areas having nitrate, ammonia, and urea in groundwater. In 2008, nitrate-nitrogen concentrations as high as about 1,000 milligrams per liter (“mg/L”) in the Overburden layer, 5,800 mg/L in the Lower Scotch Grove layer, and 4,300 mg/L in the Farmers Creek were detected in monitoring wells within the former fertilizer manufacturing plant (MACTEC, 2009).

These concentrations are well above the 10 mg/L drinking water MCL for nitrate-nitrogen. Due to the extent of the plume, the difficulty in removing nitrate from in-situ groundwater, and limits on nitrate biodegradation due to restricted bacterial energy supply (“electron donor”), this impact by nitrogenous compounds will persist for many years. As a result of these past releases of nitrogen compounds, the groundwater located within and downgradient of the Chemplex East Region and former PCS Nitrogen fertilizer plant may no longer be a viable, long-term source of potable water for downgradient areas.

The Chemplex East Region PCE plume and the nitrogen compound plume will likely comeingle. The biological breakdown of PCE and of nitrate are similar, in that both PCE and nitrate are broken down by acting as “electron acceptors”, similar to how oxygen is converted to water during animal metabolism. For both PCE and nitrate breakdown, adequate supplies of dissolved electron donor must be present to fuel microbial metabolism.

Usually, bacteria that break down nitrate will grow under less-anaerobic conditions than PCE degraders, such that the nitrate degraders may grow first. This implies that the rate of biological PCE breakdown will be limited wherever nitrate is present in the same groundwater. However, there appear to be sparse electron donor supplies downgradient of the Chemplex East Region; thus, both biological nitrogen breakdown and biological PCE degradation will be limited by the availability of electron donor, although natural attenuation by physical processes such as dispersion will continue.

3.7 Current and Potential Land and Groundwater Uses

Land use in this area is a combination of industrial, agricultural, and semi-rural residential. North of 21st Street, also known as Hawkeye Road, the VOC-impacted area is occupied by the Equistar polyethylene plant, which is expected to remain industrial. Process water used at the Equistar plant is extracted from a deep aquifer of dolomite and sandstone layers below the Maquoketa Shale, well below the zone of VOC-impacted bedrock at Chemplex (see Figure 3-1). No groundwater from above the Maquoketa Shale is currently extracted or is anticipated to be used in the Equistar plant, as these shallower layers cannot produce a flowrate sufficient for Equistar's industrial process uses.

South of 21st Street, the former fertilizer manufacturing plant has ceased operations and has been partially demolished. Due to the nitrogen-impacted soil and groundwater at this site and the ongoing cleanup, this property is expected to remain industrial. The land owners were reportedly evaluating the redevelopment of these properties for other industrial uses. Similar to the practice at Equistar, industrial developments at the former PCS Nitrogen property would likely draw groundwater from the more-productive bedrock layers located below the Maquoketa Shale.

A portion of the former fertilizer manufacturing plant was utilized in the mid-2000s as a quarry. In 2005 and 2006, there was reportedly a proposal for expansion of the quarry operations at this location. As described in the FFFS, ACC/GCC expressed concern in 2006 to the quarry operator, Preston Ready Mix, regarding the potential for a deepened quarry to cause PCE-containing groundwater to enter the quarry pit. Since 2006, ACC/GCC and EPA have not been contacted about any expansion of quarry operations, with the quarry apparently inactive.

Other parcels downgradient of the Chemplex East and West Regions are in agricultural or semi-rural residential usage. The agricultural parcels do not use well water for irrigation. There are about two dozen residences in the area downgradient of the East and West Regions. Prior to 2010, each of these residences had a private water supply well. Some of these wells were completed within the unconsolidated overburden, with the remainder screened within underlying bedrock layers. During 2009 and 2010, as part of the EPA-approved Performance Test of the "Exposure Control" alternative described in the FFFS, an extension of the City of Camanche municipal water system was constructed to serve potentially downgradient properties. Designated property owners were given the option to sign a waterline connection agreement and be connected to the expanded water system. The private water supply wells of all properties with signed connection agreements were abandoned in accordance with State procedures with the exception of one well which was converted by others for use as a monitoring well for another environmental site. A total of 20 properties were hooked up to the expanded water system, including all identified residences along 31st Avenue, which is located potentially downgradient of the East Region plume.

3.8 Summary of Human and Ecological Risks

The results of the human health risk assessment performed as part of the FFFS are summarized below. For more details regarding risk assessment, refer to Section 3.6 of the FFFS.

The risk assessment was performed based on three potential human health exposure scenarios, assuming that the groundwater extraction system was shut down:

- downgradient residents using groundwater for domestic use;
- child residents wading in Rock Creek; and
- downgradient residents exposed to intrusion of vapors from groundwater

Results of the risk assessment are summarized in the table shown below.

Risks are typically calculated for two categories, namely carcinogenic and non-carcinogenic risks. Carcinogenic risks estimate the incremental additional lifetime risk of cancer represented by hypothetical exposure to simulated, future steady-state VOC concentrations. The non-carcinogenic effects are first estimated on a compound-by-compound basis, and then added together into a single number called the “Hazard Index”. A Hazard Index exceeding 1.0 may indicate a potential for adverse non-carcinogenic health effects.

Summary of Estimated Baseline Risks to the Hypothetical Population
Downgradient of the Chemplex Site

Hypothetical Exposed Population	Hazard Index	Cancer Risk
Downgradient Residents Using Groundwater for Domestic Use	3.4	3.3×10^{-4}
Child Wading in Rock Creek	0.0017	1.6×10^{-7}
Downgradient Residents Exposed to Intrusion of Vapors from Groundwater	0.0089	4.7×10^{-7}

The Hazard Index and Cancer Risk estimated for this hypothetical exposed population represent the cumulative total of all identified exposure pathways for all of the primary VOCs found in Site groundwater. As noted, a Hazard Index greater than 1.0 may indicate a potential for adverse non-carcinogenic health effects. A cumulative Cancer Risk greater than 10^{-4} (one-in-ten-thousand) indicates that a risk to human health may exist that warrants remedial action (EPA, 1991b).

Potential risks to downgradient residents using groundwater for domestic use have been substantially reduced by the connection of most designated, potentially-downgradient residences to the City of Camanche potable water system. Further, the private water supply wells of such residences have been abandoned and are no longer available for use. Several designated residents did not elect to connect to the municipal water system. Based on available monitoring data, impacted groundwater from the Chemplex Site above MCLs has not reached any of these downgradient areas. If such a groundwater impact to these downgradient areas were foreseen in the future based on monitoring data, these residences could be connected to the municipal water system at that time, prior to any impact occurring. Any actual health risks to downgradient users are attributable to nitrate concentrations in the groundwater, and not to Chemplex chemicals, as explained in a study recently conducted by the Iowa Department of Public Health (IDPH, 2011).

The projected Hazard Index and cumulative Cancer Risk for the remaining risk scenarios, the wading child and vapor intrusion into residences, are within acceptable risk ranges.

As discussed in the FFFS, the estimated baseline risks are conservative, upper-bound estimates of hypothetical future risks to residents under the assumed exposure scenario. ACC/GCC made conservative assumptions regarding VOC concentrations in Rock Creek and in groundwater underlying the residences. For example, available information indicates that VOCs in Chemplex groundwater may be split into three potential flow regimes as this groundwater migrates downgradient from the East Region; that is, (1) a portion of the VOC mass originating from the Chemplex Site could enter the Rock Creek surface flow from the uppermost bedrock unit, with the remaining VOC mass migrating either (2) along the Rock Creek alluvial sediments, without entering the Rock Creek surface flow, or (3) under the Rock Creek alluvial channel and potentially southward toward the existing residences, potentially impacting deeper residential wells screened within the bedrock layers.

ACC/GCC's estimated hazard indices and cancer risks for the potable use and wading child scenarios are based on the conservative assumption that VOCs in migrating groundwater are not split into these three potential flow regimes, but rather travel entirely to the potential receptor without being diverted in other directions.

ACC/GCC also considered risks associated with potential intrusion of vapors from groundwater into downgradient residences. As discussed in a technical memorandum included in the June 2003 *Compendium of Technical Memoranda* (EKI, 2003e) and included as Appendix D to the FFFS, the vapor intrusion pathway was found to be insignificant due to site-specific hydrologic conditions³.

Ecological risks were evaluated as part of the FFFS. Projected VOC concentrations in surface water at Rock Creek, the Lower Rock Creek Wetlands, and the Mississippi River were compared with identified potentially-applicable water quality criteria. In all cases, concentrations were compliant with the water quality criteria. Surface waters in the Rock

³ Specifically, the PCE-impacted groundwater in the bedrock layers is overlain by clean groundwater in the shallow overburden layer, meaning that the clean water acts as a barrier for any PCE-containing vapors.

Creek, the West Tributary, and the East Tributary are routinely sampled as part of the Chemplex monitoring program. The surface water sampling locations and their associated PCE concentrations are presented on Figure 3-14.

4. DEVELOPMENT OF REMEDIAL ALTERNATIVES

4.1 New Information Regarding the Chemplex Site

The First Operable Unit (“OU-1”) Consent Decree was entered by the Court and became effective in 1991. The Consent Decree required implementing the pump-and-treat remedy that was selected under the OU-1 ROD. Since that time, extensive site-specific experience has been gained at the Chemplex Site, both as a result of 14 years of pump-and-treat operation and the performance testing of the exposure control remedy.

This site-specific experience, together with knowledge gained from similar groundwater remediation sites, has led to a review of the performance of the current Chemplex groundwater remedy. A “performance test” of an alternate groundwater remedy began in September 2008, with placement of the Chemplex groundwater remediation system into standby service. Information gained during this review is summarized below, both prior to commencement of the performance test, and during the test period.

4.1.1 Prior to Performance Test

As a result of 14 years of pump-and treat operation, better understanding of a number of factors had been gained prior to starting the performance testing:

Active reductive dehalogenation in the West Plume: Most of the PCE mass at Chemplex is present in the West Region. Based on available groundwater monitoring results and on field work done in 1997 and 1998 (EKI, 1998), there is extensive bacterial activity in the West Region of the Chemplex Site, where microbes are biodegrading PCE. This biodegradation process is called “reductive dehalogenation” or “reductive dechlorination”. The bacterial energy source, called “electron donor”, consists of hydrocarbons that were placed in or near the Chemplex landfill during the early life of the polyethylene plant, between about 1968 and 1978.

Limited reductive dehalogenation in the East Plume: Less PCE mass is found in the East Plume compared with the West Region. At the same time, the potential for biodegradation in the East Region was found to be limited due to a lesser supply of electron donor (see Section 3.2).

Distribution of nitrate and ammonia in southeast Site area: Past releases of nitrogenous compounds from former fertilizer manufacturing operations in the area southeast of the Site have resulted in substantial ammonia and nitrate concentrations under and downgradient of the former fertilizer facility. As a result of these past releases of nitrogen compounds and/or general fertilizer use in the vicinity, the groundwater located downgradient of the Chemplex East Region and former fertilizer plant may no longer be a viable, long-term source of potable water for downgradient areas. A study by the Iowa Department of Public Health (IDPH, 2011) indicated that nitrate had been detected in private drinking water wells at levels that constituted a risk of adverse health effects to infants consuming the water.

PCE concentration trends in East Plume: As described in Section 3.1.3, PCE had already migrated beyond the current Point of Compliance boundary in the southeast Site area at the time the groundwater recovery system came online in the mid-1990s. In certain wells located downgradient of the existing Point of Compliance boundary, particularly in the East Region, PCE concentrations have risen since extraction began. This increase indicates that the Chemplex groundwater recovery system was not capturing all PCE-impacted groundwater migrating downgradient within the East Region.

Naturally downward vertical gradients in the East Plume that cannot be reversed: Vertical groundwater gradients are naturally downward in much of the East Region's downgradient portion. Downward vertical gradients can carry chemical mass to lower bedrock layers, where this mass can be harder to locate and more difficult to recover. These downward vertical gradients in the East Region cannot be improved by extraction from the overlying bedrock layers, but were worsened (that is, made more strongly downward) by groundwater extraction from deeper zones.

Unreliable groundwater capture in fractured rock: As a result of the extensive fracturing of the dolomite bedrock at Chemplex, the groundwater recovery system was not able to effectively capture groundwater affected by VOCs. Due to groundwater flow through this fracture network, the hydraulic capture by the Chemplex recovery system could not be significantly improved even with the construction of additional extraction wells. Current or emerging technologies cannot identify the specific bedrock fractures that would need to be intercepted or influenced by the recovery wells to reliably control VOC migration in such fractured rock.

4.1.2 Performance Test

To protect human health and the environment more effectively, ACC/GCC proposed a revised remedial approach in the FFFS to protect potential downgradient human and ecological receptors. Under this approach, identified as Alternative 3 or "Exposure Control", the Chemplex groundwater extraction system would be shut down, and the City of Camanche municipal water service would be extended to residences with private wells located potentially downgradient of the Chemplex Site. Other components of this approach include institutional controls (that is, land use restrictions through environmental covenants, a City ordinance prohibiting groundwater well construction within the area potentially downgradient of the Chemplex Site, and agreements by the owners of such private wells to abandon such wells and not install new wells), in-situ "hot spot" treatment of groundwater, and enhanced groundwater monitoring.

Upon review of the 2007 FFFS, EPA requested a Performance Test to evaluate the Exposure Control Remedy. This test started on 29 September 2008 with the placement of the Chemplex groundwater extraction system into standby service. All major components of Alternative 3 as set forth in the FFFS have now been successfully implemented, including compilation of an extensive groundwater monitoring dataset.

Major tasks performed by ACC/GCC since the start of the performance test are listed below:

- Institutional Controls: During 2009 and 2010, several institutional controls were implemented in accordance with the *Institutional Control Plan for Chemplex Site*, prepared by MWH Americas and dated February 2009 (MWH, 2009a). These controls include:
 - an ordinance enacted by the City of Camanche that prohibits new private water supply wells in the area potentially downgradient of the Chemplex Site;
 - environmental covenants prohibiting groundwater wells screened above the Maquoketa Shale other than monitoring wells and other restrictions on the use of the Equistar property, the Cross Roads property, the Chemplex Landfill property, and the ACC/GCC property (Figure 4-1);⁴ and
 - land owner agreements to abandon private water supply wells and to not install new supply wells.
- Hot Spot Treatment: In July 2009, ACC/GCC began pilot testing treatment of localized “hot spots” of chemicals in groundwater. The pilot study applied permanganate, a strong oxidant, at one well (Well MW-108B, shown on Figure 3-10) and vegetable oil, a source of supplemental electron donor to promote biological breakdown of chlorinated ethenes such as PCE, at five wells (Wells EW-3a, EW-7b, EW-14b, MW-115A, and MW-116A, shown on Figures 3-9 through 3-11). Injection wells and selected monitoring wells were sampled over a twelve-month period to assess treatment effectiveness.

Results of this pilot test are summarized in the Hot Spot Evaluation Report (MWH, 2010b) provided in Appendix A. The pilot test showed that hot spot treatment, using either permanganate to chemically oxidize chlorinated ethenes or vegetable oil as a supplemental electron donor, was effective in remediating local hot spots with elevated PCE concentrations in groundwater. Based on these results, it is believed that in-situ treatment using vegetable oil or permanganate will be a useful component of a revised groundwater remedy for this Site.

- Waterline Extension and Abandonment of Private Wells: During 2009 and 2010, as part of the EPA-approved Performance Test of the “Exposure Control” alternative described in the FFFS, an extension of the City of Camanche municipal water system was constructed to serve designated, downgradient residences. Properties whose owners signed a connection agreement with the City were connected to the expanded water system, and the associated private water supply wells were abandoned in accordance with State procedures with the exception of one well which was converted by others for use as a monitoring well for another environmental site. A total of 20 properties were hooked up to the expanded water system, including all identified

⁴ Equistar and EPA are currently working on the Equistar environmental covenants. The Cross Roads, ACC/GCC, and Landfill covenants have been completed and recorded.

residences along 31st Avenue, which is located downgradient of the East Region plume.

- Additional Groundwater and Surface Water Sampling: Site-wide groundwater and surface water sampling rounds were performed during October 2008, December 2008, May 2009, August 2009, November 2009, May 2010, and November 2010. Additional focused sampling events were performed to help evaluate the hot spot pilot testing.

Results from these site-wide sampling rounds are discussed below.

4.1.2.1 Performance Test Sampling Results

The concentrations of PCE in groundwater before the Performance Test and after two years of pilot testing are shown graphically on Figures 3-8 through 3-13. A review of these figures indicates:

- The large majority of wells (66 out of the 72) sampled during both 2008 and 2010 had PCE concentrations in 2010 that were of the same order-of-magnitude as they were prior to the performance test;
- Three wells showed order-of-magnitude PCE decreases, namely Well MW-116A screened in the Lower Scotch Grove and Wells EW-11b and EW-14b in the Farmers Creek⁵; and
- Three wells showed order-of-magnitude PCE increases during the performance test, namely Well 3 screened in the Overburden, and Wells EW-7a and DG-21B in the Upper Scotch Grove.

PCE concentrations near the downgradient edge of the Chemplex PCE plume remained stable during the performance test period. Figure 3-15 illustrates the downgradient edge of the PCE plume, expressed as the 5 ug/L PCE contour in April 2008, prior to starting the performance testing, and then again in November 2011. As shown on Figure 3-15, the lateral extent of the PCE plume has remained stable after shutdown of the pump-and-treat system.

Surface water PCE concentrations before the Performance Test and after two years of performance testing are shown graphically on Figure 3-14. As shown on Figure 3-14, there has been no increase in PCE concentrations in surface water over the performance test period, except for location SW-3, which has alternated between approximately 1.5 ug/L and less than 0.5 ug/L during most of the performance test period. The PCE concentrations at locations SW-2 and SW-4 have remained at undetectable levels over the performance test, while concentrations at location SW-1 have dropped.

⁵ Note that two of these three wells, MW-116A and EW-14b, were injection wells for the hot-spot treatment pilot test. The injection of electron donor at these two wells was responsible for the decrease in PCE observed during the Performance Test.

4.1.2.2 Performance Test Findings

The Performance Test has demonstrated the following:

- PCE concentrations in the West Tributary, East Tributary, and Rock Creek have remained low, essentially at pre-shutdown levels.
- Based on monitoring results from the expanded well network, the downgradient edge of the PCE plume has remained stable. These monitoring results indicate the following:
 - (1) ongoing natural attenuation processes are continuing, including continued microbial reductive dechlorination in areas of the western plume, and
 - (2) a flattening of the horizontal groundwater gradient has developed due to the cessation of groundwater extraction, as illustrated on the potentiometric surface maps on Figures 3-2 through 3-7. By reducing lateral flow velocities, this flattening of the gradient is believed to allow more time for natural degradation processes to reduce PCE concentrations.
- Hot spot treatment with either permanganate or vegetable oil has been shown to effectively reduce local PCE concentrations.

Based on the Performance Test results, the Exposure Control is expected to effectively protect human health and the environment.

4.2 Proposed Updating of Cleanup Goals

In accordance with the EPA-approved *Performance Monitoring Evaluation Plan* (“PME Plan”, MWH, 2008a) and applicable addenda, designated wells are sampled and analyzed for VOCs and PAHs.

The original cleanup goals for Chemplex Site groundwater were developed during the early 1990s. Both Federal and State laws and regulations were considered. At that time, Chapter 133 of Part 567 of the Iowa Administrative Code established a hierarchy of possible requirements to be considered for each analyte. The Iowa Department of Natural Resources (“IDNR”) usually directed that the most stringent number be considered first.

For example, the original Site cleanup goal for PCE was established under Chapter 133⁶ at a concentration of 0.7 ug/L. This goal was later revised to 5 ug/L as agreed by IDNR. A concentration of 5 ug/L is the drinking water MCL for PCE.

This original goal-setting process, implemented in the early 1990s, resulted in several groundwater cleanup goals for the Chemplex Site that cannot be achieved because they are too low, well below MCLs, and cannot practicably be measured. For example, the current

⁶ Iowa Administrative Code, Section 567, Paragraph 133.4(3).

cleanup goal for vinyl chloride is 0.015 ug/L, a level that is too low to practicably measure in an analytical laboratory. In comparison, the current drinking water MCL for vinyl chloride is 2 ug/L, a concentration that is over 100 times above the current Site groundwater cleanup goal.

The Site's groundwater cleanup goals should be modified to bring them into compliance with current State and Federal practice and to establish and apply these goals on a consistent basis. MCLs are typically applied as cleanup goals for certain groundwater sources unless meeting MCLs is found to be technically impracticable from an engineering perspective.

ACC/GCC proposes to streamline the current groundwater monitoring approach and to bring the cleanup goals in line with current MCLs and other current practices. Data collected to date at Chemplex has also been considered. As a result, ACC/GCC makes the following proposals for EPA's consideration:

- (1) For VOCs, cleanup levels are proposed to be updated to match current Federal and State drinking water MCLs.
- (2) For benzo(a)pyrene, a PAH, the existing cleanup level of 0.2 ug/L, which is equal to the drinking water MCL, is proposed to remain in place.
- (3) For naphthalene, a PAH that has no drinking water MCL, the cleanup level is proposed to be modified to 1.4 ug/L to be consistent with current EPA, Region 7 practice.
- (4) For metals of interest at Chemplex, cleanup levels are proposed to be revised to MCLs.

The current and proposed cleanup goals for VOCs, PAHs, and metals are summarized in Table 4-1. Supporting information is presented below.

4.2.1 VOCs

The PME Plan calls for VOC testing of designated "Area of Attainment" wells and several private water supply wells. As shown in Table 4-1, the current cleanup goals for most VOCs are similar to MCLs. To reflect updated Site information while maintaining protection of human health, the following cleanup goals are proposed:

- Benzene: The current groundwater cleanup standard of 1 microgram per liter ("ug/L") is less than the drinking water MCL of 5 ug/L. As shown in Table 4-1, the proposed cleanup goal is 5 ug/L.

- 1,2-Dichloroethene, or “1,2-DCE”: The current cleanup standard of 70 ug/L encompasses the sum of the “cis” and “trans” isomers of 1,2-DCE.⁷ The current MCLs for 1,2-DCE are now broken down by specific isomer—the MCLs for the “cis” and “trans” isomers are now 70 and 100 ug/L, respectively. The cleanup goals for these two isomers are proposed to equal their current MCLs.
- 1,1,2,2-Tetrachloroethane: In recent groundwater sampling events, 1,1,2,2-tetrachloroethane was not detected above the current cleanup standard, and therefore does not appear to be a chemical of concern at this Site; thus, it is proposed that the cleanup standard be deleted and that this analyte be deleted from the list of chemicals of concern for the Chemplex Site.
- TCE: The current cleanup standard of 3 ug/L is proposed to be changed to the current MCL of 5 ug/L.
- Vinyl Chloride or “VC”: The current cleanup standard of 0.015 ug/L, equivalent to 15 parts-per-trillion, is too low to measure using commercially-available laboratory analytical equipment. The proposed cleanup standard of 2 ug/L, equivalent to the current drinking water MCL, could be tested for in the laboratory, with practicable detection limits depending on the levels of other VOCs.

4.2.2 PAHs

As shown in Table 4-1, cleanup standards were established at Chemplex for two PAH compounds: benzo(a)pyrene and naphthalene. PAHs have only rarely been detected in downgradient groundwater. At Chemplex, as at most PAH sites, they appear to be essentially immobile, as they have never been detected outside the current Point of Compliance boundary. ACC/GCC does not propose changing the existing cleanup goals of 0.2 ug/L for benzo(a)pyrene since it is equal to the current MCL. To be consistent with current EPA, Region 7 practice, ACC/GCC proposes changing the cleanup goal for naphthalene to 1.4 ug/L as noted in Table 4-1

4.2.3 Metals

Table 4-1 shows the cleanup goals established at the start of the Chemplex remediation for antimony, arsenic, and barium. These analytes are either rarely found above the current cleanup levels (in the cases of antimony and barium) or do not appear to be widespread at levels elevated above background concentrations (in the case of arsenic). Cleanup levels for these metals are proposed to be revised to the current MCLs.

⁷ These two “isomers” have the same chemical structure, but have different configurations that make their chemical behavior slightly different. When the project PME Plan was prepared during the early 1990s, analytical instruments commonly available at the time could not easily differentiate between these two isomers, and therefore their standard was expressed as a combined concentration for both isomers. Current laboratory equipment can provide separate concentrations for each isomer.

4.3 Remedial Action Objectives for Groundwater

Subsection 300.430(a)(1)(F) of the National Oil and Hazardous Substances Pollution Contingency Plan (“NCP”) states that EPA’s expectations for groundwater remediation are as follows:

EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.

Consistent with EPA’s expectations for groundwater remediation, ACC/GCC has developed the following overall goals for groundwater remediation:

- Prevent human exposure to contaminated groundwater above acceptable risk levels
- Mitigate further migration of the contaminant plume.

ACC/GCC has also evaluated how to further reduce site risks.

Remedial Action Objectives are quantitative goals that define the extent of cleanup required to protect human health and the environment and to comply with the Applicable or Relevant and Appropriate Requirements (“ARARs”) discussed below in Section 4.4. The groundwater cleanup levels for this site, outside the boundary of any established Point of Compliance boundary or Technical Impracticability zone, are proposed to be equivalent to drinking water MCLs because MCLs are legally enforceable standards for drinking water. These proposed groundwater cleanup levels are presented in Table 4-1.

The following Remedial Action Objectives have been developed to guide the selection and implementation of remedial approaches. The FFFS provides detail and information regarding the derivation of these objectives.

Remedial Action Objective 1: Prevent human exposure to VOCs in groundwater and accessible surface waters at levels greater than a cumulative Hazard Index of 1.0 for non-carcinogenic risks and a cumulative incremental lifetime cancer risk exceeding the range of 10^{-4} (one in ten thousand) to 10^{-6} (one in one million).

- The Hazard Index is defined as the sum of the estimated non-carcinogenic risks for each VOC to which an individual may be exposed in the form of groundwater. Each VOC’s contribution to the Hazard Index is the estimated potential dosage divided by the “reference dose”, for drinking water exposures and other oral exposures, or the “reference concentration”, for inhalation exposures.

- Carcinogenic risks are estimated by multiplying the projected dosage for each VOC by either (1) the Cancer Slope Factor, for drinking water exposures and other oral exposures, or (2) the Unit Risk Factor, for inhalation exposures.

Remedial Action Objective 2: Limit exposure by potential ecological receptors in Rock Creek and downgradient surface waters to:

- PCE at levels exceeding 98 ug/L in designated surface waters,
- TCE at levels exceeding 80 ug/L,
- 1,2-DCE at levels exceeding 590 ug/L, and
- Vinyl chloride, or “VC”, at levels exceeding 930 ug/L.⁸

Remedial Action Objective 3: Prevent migration of Site-related chemicals, above the health-based concentrations described in Remedial Action Objective 1, to those portions of downgradient areas where groundwater is considered to be potentially usable as a potable water supply.

If cancer-related risks are projected to exceed the 10^{-4} level based on assessment of the potential risk posed by site conditions, then cleanup is required and the 10^{-6} level will be used as the “point of departure” for evaluating remedial alternatives. If the cancer-related risk is between 10^{-4} and 10^{-6} , EPA will determine if cleanup is necessary. Cleanup is generally not required if the cancer-related risk is less than 10^{-6} .

4.4 Applicable or Relevant and Appropriate Requirements

The Chemplex Site remediation is conducted under the Comprehensive Environmental Response, Compensation and Liability Act as amended (“CERCLA”), also called “Superfund”. Remedial actions under CERCLA, including those at the Chemplex Site, must be analyzed for compliance with the “Applicable or Relevant and Appropriate Requirements” (also called “ARARs”) of environmental laws other than CERCLA.

An environmental protection requirement established under environmental laws other than CERCLA—that is, an ARAR—may be either “applicable” or “relevant and appropriate” to a Superfund cleanup. When determining potential ARARs for a remedial action, a two-tier test applies. First, determine whether the requirement is applicable. Second, if the requirement is not applicable, then determine whether the requirement is nevertheless relevant and appropriate.

“Applicable” environmental protection requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that specifically address a

⁸ See Page 4-6 of the FFFS for the rationale for these levels.

hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. Applicable requirements are compulsory – that is, a specific state or federal law or regulation mandates that any remedial action adhere to the applicable requirement.

In turn, “relevant and appropriate” requirements are those cleanup standards, standards of control, or other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility citing laws that do not directly and fully address site conditions, but which involve similar situations or problems to those encountered at a CERCLA site. Whether a requirement is relevant and appropriate depends on factors such as the duration of the response action, the form or concentration of the chemicals present, the nature of the release, or the availability of other standards that more directly match the circumstances at the site.

Only the substantive portions of a law or regulation are to be considered potential ARARs. Administrative or procedural requirements, such as permitting or record-keeping requirements, are not considered ARARs.

Standards, limits, guidance, or advisories that do not qualify as promulgated laws and regulations may nonetheless be taken into account when determining the remedial approach at a site. Such non-promulgated guidance or advisories are “To Be Considered” (“TBC”) criteria. TBC criteria are not legally-binding requirements, and therefore do not have the same status as potential ARARs. TBCs, however, may be evaluated and considered along with ARARs. Examples of TBCs include peer reviewed health effect information, guidance documents or policy documents, and local zoning requirements. Although TBCs are not ARARs, compliance with TBCs may be taken into account to protect human health or the environment.

Determining applicability, relevance and appropriateness, and TBC compliance occurs on a site-specific basis. There are three types of ARARs: chemical-specific, location-specific, and action-specific.

Chemical-specific ARARs include those laws and requirements that regulate the release of materials possessing certain chemical or physical characteristics, or containing specified chemical compounds. These requirements are generally health- or risk-based restrictions on the amount or concentration of a chemical that may be found in, or discharged to, the environment. If a chemical is subject to more than one discharge or exposure limit, the more stringent requirement generally should be applied.

Location-specific ARARs are those requirements that relate to the geographical or physical location of the site or remedial action, rather than the nature of the chemicals or the proposed remedy. Location-specific ARARs are intended to prevent damage to unique or sensitive areas, such as floodplains, historic places, wetlands, and fragile ecosystems, and restrict other activities that are potentially harmful because of where they occur. These requirements may limit the type of implementable remedial action, or may impose additional constraints.

Action-specific ARARs depend on the activity or technology implemented. They can involve the design or use of certain equipment, or regulate specific remedial activities. Action-specific ARARs generally set performance or design standards for specific activities related to the handling, treatment, transportation, and disposal of wastes. They apply not because of the presence of specific chemicals at a site, but rather because of the remedial technique, technology, or approach selected to accomplish a remedy.

The ARARs and TBCs for the Chemplex groundwater remediation are compiled in Table 4-2 (for Alternative 2, “Pump and Treat”), and Table 4-3 (for Alternative 3, “Exposure Control”). Each of these tables is divided into three sub-tables, labeled, “A”, “B”, and “C”, that respectively discuss potential Chemical-Specific, Location-Specific, and Action-Specific ARARs for each of the three remedial alternatives.

Applicable or relevant and appropriate requirements may be waived in accordance with Section 121(d)(4) of CERCLA, Section 300.430(f)(1)(ii)(C) of the NCP, and pertinent EPA guidance.

4.5 Institutional Controls

Institutional controls are administrative or legal restrictions imposed on access to or use of land and groundwater. These restrictions are intended to prevent potential exposure to chemicals of concern or to prevent activities that might otherwise interfere with the effectiveness of a response action. Examples of institutional controls are proprietary controls, governmental controls, enforcement or permit tools, and informational tools.

Proprietary controls include restrictive covenants to limit a particular use of land or groundwater. Such controls can also include easements that grant physical access by regulatory agencies and private parties for the performance of response actions. Governmental controls include zoning, well drilling prohibitions, groundwater management zones, and local ordinances. Enforcement or permit tools include consent decrees or orders as well as permits that restrict the use of property and impose response action obligations. Informational tools include state registries of contaminated properties, deed notices, and advisories. Informational tools are generally used as a secondary measure to help ensure the overall reliability of other institutional controls.

The effectiveness of institutional controls is dependent on the mechanism used and that mechanism’s durability. Proprietary controls can expire after a certain number of years and may be vulnerable to inadvertent elimination if foreclosure or bankruptcy occurs. Further, regulatory agencies may not be able to enforce proprietary controls because the agency does not hold a property interest in the site or the adjoining land.

To address these potential limitations of institutional controls, the State of Iowa enacted the Uniform Environmental Covenants Act in 2005 to provide activity and use limitations on land and groundwater through environmental covenants. The Uniform Environmental Covenants Act is a mechanism for creating, enforcing, modifying, and terminating environmental covenants. The environmental covenants must be recorded in the local land records to provide notice to others of the existence of activity and use limitations. EPA and the State of

Iowa, as well as local governments, have the right to enforce these environmental covenants. The restrictions contained in an environmental covenant are binding on the parties who acquire the property in the future. Further, the environmental covenants cannot be incidentally removed through foreclosure or bankruptcy or other occurrences. Iowa's environmental covenants law applies to all remedial actions under state law regardless of the particular state cleanup programs used and also applies to remedial actions conducted under EPA oversight. Such environmental covenants can be an effective and durable tool for reducing the risk of exposure to chemicals of concern.

4.6 Technology and General Response Action Screening Assessment

Section 4.6 of the FFFS included a detailed technology screening assessment for the Chemplex Site. A wide range of technologies were evaluated as part of this assessment, including in-situ chemical oxidation, in-situ anaerobic biodegradation, bioaugmentation, permeable barrier, thermal treatment, chemical mobilization, natural attenuation, aerobic biodegradation and volatilization, gaseous nutrient addition, enhanced containment, electron acceptor diversion, phytoremediation, enhanced extraction, reactive wall, containment, and engineering and institutional controls to limit potential exposure.

Based on the screening assessment, the following technologies were retained for further evaluation:

For Source Zone Remediation:

- Natural attenuation

For Dissolved-Phase VOC Removal:

- In-situ chemical oxidation for localized hot-spot treatment
- In-situ anaerobic biodegradation for localized hot-spot treatment
- Containment
- Engineering and institutional controls to limit potential exposure
- Natural attenuation

For further details regarding this technology screening evaluation, see Section 4.6 of the FFFS.

Section 4.7 of the FFS developed the following remedial approaches based on the retained technologies:

- No further action
- Institutional controls only
- Institutional controls and monitoring
- Hydraulic containment by pump-and-treat
- Hydraulic containment in East Region
- In-situ chemical oxidation (for localized hot-spot treatment)
- In-situ anaerobic biodegradation (for localized hot-spot treatment)
- Engineering controls to limit exposure

The above approaches, called “General Response Actions” were evaluated based on the criteria of effectiveness, implementability, and cost. Based on this evaluation, the following General Response Actions were retained:

- No further action (required to be retained under the NCP)
- Institutional controls and monitoring
- Hydraulic containment by pump-and-treat
- In-situ chemical oxidation (for localized hot-spot treatment)
- In-situ anaerobic biodegradation (for localized hot-spot treatment)
- Engineering controls to limit exposure

For further details regarding this General Response Action screening evaluation, see Section 4.7 of the FFFS.

4.7 Description of Groundwater Remedial Alternatives for Detailed Evaluation

Three comprehensive remedial alternatives were evaluated in detail, based on the General Response Actions described in Section 4.6:

- 1) “No Further Action”
- 2) “Pump-and-Treat Remedy”
- 3) “Enhanced Exposure Control”

Alternative 1, or the No Further Action alternative, was described and evaluated in the FFFS. Under this alternative, the groundwater recovery system would be shut down and no further action would be undertaken beyond system demolition. For a detailed evaluation of Alternative 1, please see Section 4.8.1 of the FFFS. In the FFFS, Alternative 1 was determined to be not protective and not compliant with ARARs; therefore, this No Further Action alternative is not discussed further in this updated document.

Alternatives 2 and 3 are discussed in this Section, with components of each alternative described under the following five categories:

- 1) Institutional Controls – Environmental covenants or other legal or administrative means of limiting potential exposure to contaminants.
- 2) Active Remediation – Actions taken to decrease the extent, concentration, or toxicity of the groundwater plumes.
- 3) Engineering Controls – Physical methods to limit potential exposure to contaminants.
- 4) Monitoring – Level gauging, sampling, and analysis of groundwater to evaluate plume behavior.
- 5) Potential Contingency Measures – Actions that can be taken, after appropriate technical evaluations and discussions with regulatory agencies, to maintain protectiveness.

Table 4-4 lists the components of each groundwater alternative.

4.7.1 Alternative 2: Pump-and-Treat Remedy

Under this remedial alternative, the Chemplex groundwater recovery and treatment system would operate indefinitely in the pump-and-treat configuration operated from late 1994 to September 2008.

4.7.1.1 Institutional Controls

Under Alternative 2, the existing covenants restricting the use of groundwater and required under the OU-1 Consent Decree would remain in place. The existing Point of Compliance boundary would be kept in place.

4.7.1.2 Active Remediation

Under Alternative 2, groundwater extraction and treatment would be maintained. Groundwater would be extracted from approximately 30 extraction wells screened in the Overburden and Upper Scotch Grove bedrock layer, similar to the operating procedures prior to the performance test. VOCs in the extracted groundwater would be removed in two air stripping towers. A portion of the flow would be treated by granular activated carbon adsorption. The treated effluent would be discharged to the Mississippi River under a NPDES permit.

4.7.1.3 Engineering Controls

Under Alternative 2, existing fencing, signs, caps, and covers would be maintained around the Chemplex Landfill and other areas designated under the Second Operable Unit.

4.7.1.4 Monitoring

Under Alternative 2, monitoring of in-situ groundwater and treatment of extracted groundwater would continue under the original PME Plan. ACC/GCC would continue groundwater gauging and monitoring in accordance with the PME Plan.⁹

ACC/GCC would continue to monitor treated groundwater to determine compliance with the Site's NPDES permit.

4.7.1.5 Contingency Measures

As described in Section 3.4.3, due to the fractured bedrock environment the existing extraction well network cannot be enhanced with additional extraction wells to reliably capture all PCE-containing groundwater that is migrating downgradient. This is particularly

⁹ A revised PME Plan (MWH, 2008a) and two addenda to the PME Plan have been developed in connection with the Performance Test of Alternative 3. Under Alternative 2, it is assumed that the monitoring plan would return to the original PME Plan dating from 1993.

so in the East Region. As described in Sections 3.4.2 and 3.4.3, PCE that has already migrated into rock pores will back-diffuse out of the pores of the fractured bedrock into groundwater, serving as an ongoing, long-term source of dissolved PCE mass.

If chemical detections in surface water exceed applicable water quality criteria, the affected areas could be fenced off and warning signs posted. Localized aeration of stream segments could also be done if needed.

4.7.2 Alternative 3: Enhanced Exposure Control

Alternative 3 includes several components to control potential exposure to impacted groundwater. A key component is expansion of the City of Camanche water system to residences located downgradient of the Chemplex groundwater plumes. As discussed previously, this component was successfully implemented during 2010.

As part of Alternative 3, the existing pump-and-treat groundwater remediation system would be permanently shut down and demolished.

4.7.2.1 *Institutional Controls*

Alternative 3 included the following institutional controls outlined in the Institutional Control Plan (MWH, 2009a):

- an ordinance enacted by the City of Camanche that prohibits new private water supply wells in the area downgradient of the Chemplex Site;
- environmental covenants on certain properties, including the Equistar property, the Cross Roads Property (i.e., the former PCS Nitrogen property), the Chemplex Landfill property, and the ACC/GCC property that:
 - prohibit the construction of wells screened above the Maquoketa Shale layer for human consumption, livestock watering, or agricultural use;
 - require that all new wells constructed through the Maquoketa Shale formation and screened within underlying layers be sealed during construction and operation to the satisfaction of IDNR and EPA;
 - require the written permission of IDNR and EPA prior to abandoning or removing a well from the site;
 - prohibit the residential use of the property;
 - prohibit the extraction from dewatering wells or sumps as well as any activity that may interfere with groundwater monitoring or other monitoring activities, groundwater extraction and treatment, or any other remedial action required by governmental authority; and

- grant access to EPA, IDNR, ACC/GCC, and their authorized contractors to conduct activities required by EPA or IDNR.

As part of the Performance Test of Alternative 3, all of the above institutional controls have now been implemented, with the exception of the Equistar and Landfill environmental covenants which are currently under review by EPA and are believed to be nearing execution and official recordation.

The boundaries of the environmental covenants and City well ordinance areas are shown on Figure 4-1.

4.7.2.2 *Active Remediation*

Under Alternative 3, the Chemplex existing pump-and-treat groundwater remediation system would be permanently shut down and then demolished or abandoned in place.

Upon permanent system shutdown at the end of the mothballing period, selected extraction wells would be converted to monitoring wells. Other extraction and monitoring wells not needed for continued gauging and monitoring would eventually be abandoned in accordance with State well abandonment procedures. Groundwater extraction and treatment equipment, including well pumps, would be permanently removed from service. The existing Treatment Building, Blower Building, and Lift Stations would be demolished. Buried piping and conduits would be abandoned in place.

In an effort to address localized PCE “hot spots”, a strong oxidant, such as permanganate, or an electron donor, such as vegetable oil, would be applied into designated monitoring wells. A pilot study of the “hot spot” treatment approach was performed by MWH under contract to ACC/GCC starting in July 2009. The pilot study applied permanganate at one well and vegetable oil at five wells at the Site. Injection wells and selected monitoring wells were sampled over a twelve-month period to assess treatment effectiveness.

Results of this pilot test were summarized in the Hot Spot Pilot Test Evaluation Report submitted to EPA in December 2010 (MWH, 2010b), provided as Appendix A. The pilot test showed that hot spot treatment, using either permanganate to chemically oxidize chlorinated ethenes or vegetable oil as a supplemental electron donor, was effective in remediating local hot spots with elevated PCE concentrations in groundwater.

In the future, hot spot areas would be identified on a case-by-case basis in cooperation with EPA. The procedure for designating a hot spot cannot be exactly defined in advance. For example, a rise in PCE concentration in an upgradient monitoring well might be regarded as acceptable if PCE in this area would be unlikely to affect downgradient concentrations outside the boundary of an established Technical Impracticability (“TI”) zone. A similar concentration increase might not be deemed acceptable in a well located near a downgradient TI zone boundary.

Such an approach would be consistent with Remedial Action Objective 3 as described in Section 4.3, which seeks to prevent chemical migration above health-based levels to downgradient areas where groundwater is considered to be usable as a potable water supply. Although it would not be expected that ARARs would be achieved within an established TI zone, such a hot spot effort could reduce the potential for chemical migration outside the zone above health-based levels.

EPA and ACC/GCC would discuss each year's monitoring data during an annual conference call, with possible hot spots addressed on a case-by-case basis as determined by EPA considering concentration trends, well location, and the potential for exposure. For each hot spot identified in this fashion with EPA, ACC/GCC would submit a workplan compiling available data, specifying oxidant type or electron donor type and injection location, and defining follow-up monitoring.

4.7.2.3 *Engineering Controls to Reduce the Potential for Exposure*

Alternative 3 includes a westward extension of the City of Camanche municipal potable water system along 9th Street to serve designated residences located south of the Chemplex Site. During 2009 and 2010, as part of the EPA-approved Performance Test of the "Exposure Control" alternative described in the FFFS, this extension of the City of Camanche municipal water system was constructed to serve designated, potentially-downgradient residences. Property owners signed a connection agreement with the City and were connected to the expanded water system. Pursuant to the agreements, the private water supply wells of residents signing the connection agreement were abandoned in accordance with State procedures or, in one case, converted by others for use as a monitoring well for another environmental site. The agreements further provide that no new wells may be installed on the properties. A total of 20 properties were hooked up to the expanded water system, including all identified residences along 31st Avenue, which is located potentially downgradient of the East Region plume. The location of this westward extension is shown by the orange line on Figure 4-1.

4.7.2.4 *Monitoring*

Tables 4-5 describes the monitoring program under Alternative 3, which was outlined in PME Plan Addendum 2 (MWH, 2011), provided as Appendix B. Refer to Appendix B for sampling and gauging locations. In general, sampling and gauging events would be performed semiannually, once in the Spring and once in the Fall. All samples would be analyzed for VOCs under EPA Method 8260B or similar EPA-approved method. Additional monitoring may be deemed necessary based on results from routine monitoring.

4.7.2.5 *Contingency Measures*

Contingency measures for Alternative 3 were developed and were documented in the *Final Contingency Plan for Exposure Control Performance Test*, dated 19 September 2008 (EKI, 2008b). The contingency procedures described in the Contingency Plan have been updated to be consistent with current conditions and the proposed TI waiver. The updated contingency procedures are described below.

As a framework for determining whether contingency actions are appropriate in a given situation, ACC/GCC divided the Chemplex Site and its downgradient areas into four groundwater monitoring zones, shown on Figure 4-2. The corresponding monitoring zone for each monitoring well is discussed in Table 4-5. These four groundwater monitoring zones are as follows:

- **Routine Monitoring Zone:** Shown in blue on Figure 4-2, this Zone encompasses the approximate lateral extent of the current Chemplex VOC plume. Since elevated VOC concentrations in the Routine Monitoring Zone are expected, elevated concentrations at Routine Monitoring Zone wells would not trigger any contingency actions.
- **Contingency Well Trigger Zone:** Shown in green on Figure 4-2, this Zone encompasses the area immediately downgradient of the current plume boundary, including the area immediately east of the Eastern Un-Named Tributary. It is expected that VOCs will be detected in parts of this Zone in the future. As there are no potable water supply wells within this Zone, such detections would not result in exposures to VOC-containing groundwater by potential human receptors. Given these conditions, the only potential contingency action that would be triggered by elevated concentrations in the Contingency Well Trigger Zone would be the construction of additional contingency monitoring wells to further enhance the well network.
- **Heightened Awareness Zone:** Shown in orange on Figure 4-2, this Zone encompasses the area immediately south of Rock Creek. Confirmed detections of elevated VOC concentrations at monitoring wells located in this Zone could require contingency measures beyond additional monitoring well construction.
- **Expedited Contingency Zone:** Shown in red on Figure 4-2, this Zone encompasses the area downgradient of the Heightened Awareness Zone and upgradient of known private water supply wells. Elevated VOC concentrations in this Zone could lead to possible exposure by human receptors; therefore, elevated concentrations in this Zone would trigger expedited contingency measures to mitigate potential human exposure to VOC-containing groundwater, vapor, or surface water.

If certain concentration levels are confirmed to be exceeded in groundwater wells located in the Contingency Well Trigger Zone, the Heightened Awareness Zone, or the Expedited Contingency Zone, appropriate groundwater contingency measures would be triggered, as discussed below.

Selection of appropriate contingency measures would depend on the location and magnitude of the observed VOC concentrations. Three contingency scenarios, corresponding to three levels of response, called “Level 1”, “Level 2”, and “Level 3”, are proposed. These contingency scenarios are described below, along with response actions to be implemented.

- **Contingency Level 1:** The Level 1 contingency scenario would be triggered if any VOC of concern at the Chemplex Site is detected in a Contingency Well Trigger Zone

groundwater well at confirmed levels greater than the trigger levels shown in Table 4-6.

If any Contingency Well Trigger Zone well contains a VOC concentration greater than the trigger levels shown in Table 4-6, the well would be resampled within 14 days of receipt of the analytical results depending on existing weather and field conditions. ACC/GCC would inform EPA if field conditions preclude resampling within 14 days. If this confirmation sampling confirms the exceedance, the Level 1 contingency procedure described below would be implemented upon receiving direction or concurrence from EPA.

Under the Level 1 Contingency Scenario, ACC/GCC would construct a new contingency well or well cluster as identified in Table 4-7. The new contingency well cluster would be gauged and sampled for VOC analysis on a semiannual basis, and would be performed in accordance with the most recent Performance Monitoring Evaluation Plan, Quality Assurance Project Plan, and sampling protocols. The new Contingency Well would be constructed within approximately 120 days of receiving the confirmation sampling results described above, with sampling and analysis to proceed as soon as feasible.

- Contingency Level 2: The Level 2 contingency scenario would be triggered if any VOC of concern at the Chemplex Site is detected in a Heightened Awareness Zone groundwater well at a confirmed level greater than the trigger levels shown in Table 4-6.

If any Heightened Awareness Zone well contains a VOC concentration greater than the trigger levels shown in Table 4-6, the well would be resampled within 14 days of receipt of the analytical results depending on existing weather and field conditions. ACC/GCC would inform EPA if field conditions preclude resampling within 14 days. If this confirmation sampling confirms the exceedance, the Level 2 contingency procedure described below would be implemented.

Under the Level 2 Contingency Scenario, ACC/GCC would perform the following contingency actions upon receiving direction or concurrence from EPA:

- The sampling frequency for monitoring wells in the Heightened Awareness Zone and Expedited Contingency Zone would be increased to four times per year for one year. After this year of increased monitoring, ACC/GCC would reassess the monitoring frequencies in these Zones in conjunction with EPA.
- If indicated by Table 4-7, a new contingency well or well cluster would be constructed. The new contingency well cluster would be sampled for VOC analysis upon its construction and development, and then subsequently at the same frequency as the other wells located in the Heightened Awareness Zone. The additional well or wells would be gauged semiannually.

- The Contingency Well would be constructed within 120 days of receiving the confirmation sampling results described above, with sampling and analysis to proceed as soon as feasible. Sampling, gauging, and laboratory analysis would be done in accordance with the most recent Performance Monitoring Evaluation Plan, Quality Assurance Project Plan, and sampling protocols. If the contingency well cluster listed in Table 4-7 has already been constructed due to a previous exceedance, no new contingency wells would be required to be constructed.
- Within 60 days of receiving the confirmation results, ACC/GCC would submit to EPA a Technical Memorandum evaluating the need for additional contingency measures beyond those described above. In the Technical Memorandum, the feasibility of several potential contingency measures would be evaluated based on factors such as groundwater flow direction and plume characteristics. The contingency measure most likely to be considered under this Level 2 scenario would be expected to be additional “hot spot” treatment using chemical oxidation or enhanced bioremediation.
- Contingency Level 3: The Level 3 contingency scenario would be triggered if any VOC of concern at the Chemplex Site is detected in an Expedited Contingency Zone groundwater well at a confirmed level greater than the trigger levels shown in Table 4-6.

If any Expedited Contingency well contains a VOC concentration greater than the trigger levels shown in Table 4-6, the well would be resampled within 14 days of receipt of the analytical results depending on existing weather and field conditions. ACC/GCC would inform EPA if field conditions preclude resampling within 14 days. If this confirmation sampling confirms the exceedance, the Level 3 contingency procedure described below would be implemented.

Under the Level 3 Contingency Scenario, ACC/GCC would perform the following contingency actions upon receiving direction or concurrence from EPA:

- For a period of one year following the confirmed exceedance, private residential wells located potentially downgradient of the exceedance would be sampled on a semiannual basis by the Clinton County Health Department. The sampling and chain-of-custody documentation would be observed by an ACC/GCC representative in order to confirm the integrity of the sampling procedures. Sampling and analysis costs would be paid for by ACC/GCC. Following the initial year of monitoring, ACC/GCC, in conjunction with EPA, would assess the need for any additional monitoring.

- For a period of one year following the confirmed exceedance, vapor sampling would be performed on a semiannual basis at residences located downgradient of the exceedance. Sampling procedures and trigger levels would be defined in a Vapor Monitoring Workplan to be submitted to EPA within 30 days of the confirmed exceedance. The sampling procedures described in the Work Plan would be tailored to the existing conditions at each individual residence being monitored, with preference given to sub-slab or basement monitoring over sampling within living spaces to reduce the likelihood of interferences from residential sources.

In the event that VOCs are detected in vapor samples at levels exceeding the trigger levels specified in the Vapor Monitoring Work Plan, additional steps would be considered to address the vapor pathway. These additional steps would depend on the specific VOCs detected and would be determined based on consultation with EPA, and could include the installation of a vapor monitoring system.

All vapor sampling and analysis costs would be paid for by ACC/GCC. Following the initial year of vapor monitoring, ACC/GCC, in conjunction with EPA, would reassess the need for additional vapor monitoring.

- If there are any private residences potentially downgradient of the confirmed exceedance that are not connected to the Camanche water line, ACC/GCC would provide these residences with a granular activated carbon (“GAC”)-based home water treatment device with carbon changeout service for a period satisfactory to EPA. ACC/GCC would endeavor to provide these devices within 15 days of the confirmed exceedance, although the exact timeframe will depend on the availability of treatment equipment and ease of installation and connection.
- Within 60 days of receiving the confirmation results, ACC/GCC would submit to EPA a Technical Memorandum evaluating the need for additional proposed contingency measures beyond those described above. In the Technical Memorandum, the feasibility of several potential contingency measures would be evaluated based on factors such as groundwater flow direction and plume characteristics. The primary contingency measures likely to be considered under this Level 3 scenario would be expected to be (1) additional “hot spot” treatment using chemical oxidation or enhanced bioremediation, and (2) further extension of the Camanche water line. The Technical Memorandum would describe detailed procedures for the selected contingency measures as well as a schedule for implementation.

For surface water, a contingency scenario would be triggered if any VOC is detected in a designated surface water sampling location at confirmed levels greater than the trigger levels

shown in Table 4-6. If any surface water sampling location contains a VOC concentration greater than the trigger levels shown in Table 4-6, the location would be resampled within 14 days of receipt of the analytical results depending on existing weather and field conditions. ACC/GCC would inform EPA if field conditions preclude resampling within 14 days. If this confirmation sampling confirms the exceedance, the contingency procedure described below would be implemented under the Surface Water Contingency scenario:

- Within 45 days of receiving the confirmation results, ACC/GCC would erect signs in the area of the exceedance to inform people planning to use the surface water body for recreation about the possible hazard, subject to the concurrence of property owners. To the extent feasible based on field conditions and approvals from property owners, localized fencing would be installed to limit recreational access to the surface water body at the location of the exceedance, if not already fenced or located on secure property.
- Within 30 days of receiving the confirmation results, ACC/GCC would submit to EPA a Technical Memorandum evaluating the need for additional contingency measures beyond those described above, including, if appropriate, measures to protect ecological receptors. In the Technical Memorandum, the feasibility of several potential contingency measures would be evaluated. The primary contingency measures likely to be considered under this scenario would be expected to be (1) additional fencing, and (2) creek aeration in the area or areas with elevated VOC concentrations. The Technical Memorandum would describe procedures for the selected contingency measures as well as a schedule for implementation.

4.7.2.6 *Technical Impracticability (“TI”) Zone*

The updated *Technical Impracticability Evaluation Report* is attached as Appendix D to this Updated FFS. Prepared in accordance with EPA guidance, this report proposes that, under Alternative 3, a Technical Impracticability (“TI”) zone be established where shown on Figure 4-3. ACC/GCC proposes that the cleanup levels be waived within this TI zone for the specific analytes indicated in the right column of Table 4-1. The cleanup goals listed in Table 4-1 would remain in effect for areas downgradient of this TI zone. The existing Point of Compliance boundary would no longer be in effect since the TI zone would serve the same purpose.

Pasturing, farming, or industrial reuse would not be affected as long as such uses have no detrimental effect on the groundwater remedy.

The proposed TI zone boundaries, shown on Figure 4-3, were drawn using the following criteria:

- The western TI Zone boundary is close to the boundary line of the site, including a portion of the West Tributary. This boundary was drawn generally parallel to the 5 ug/L concentration contour based on the most recent available groundwater monitoring data.

- The eastern TI Zone boundary encompasses the East Tributary, while excluding areas not known to contain elevated PCE concentrations. The boundary was drawn generally parallel to the 5 ug/L PCE concentration contour based on the most recent available groundwater monitoring data.
- The northern (upgradient) TI Zone boundary was drawn based on the inferred PCE plume boundary at a concentration of 5 ug/L with the 1992 PCE data used in areas where more recent data were not available.
- The southern (downgradient) TI Zone boundary was drawn based on the existing 5 ug/L PCE concentration contour, with an extension southward to allow for matrix diffusion with a further extension in the southeastern zone corner to account for the presence of existing elevated nitrate concentrations in this area.

5. COMPARATIVE ANALYSIS OF ALTERNATIVES

This section compares the remedial alternatives described in Section 4.7. This comparison was done in accordance with applicable EPA guidance.¹⁰

5.1 Criteria for Analysis

Section 4 described the remedial alternatives that have been retained for consideration in this Updated FFS. Consistent with the NCP¹¹, Section 5 evaluates these remedial alternatives in detail. This detailed analysis consists of an assessment of individual alternatives against each of nine evaluation criteria (the “NCP criteria”), and a summary comparative analysis describing the relative performance of each alternative against those criteria.

The nine NCP criteria are described below. They are divided into three groups: Threshold Criteria, Balancing Criteria, and Modifying Criteria.

To be considered as a remedial alternative meriting implementation, each alternative must, at a minimum, comply with the following two “Threshold Criteria:”

Threshold Criteria:

- **Protectiveness:** Short-term and long-term protection of human health and the environment from unacceptable risks posed by hazardous substances released into the environment.
- **Compliance with ARARs:** Compliance with Applicable or Relevant and Appropriate Requirements (“ARARs”), unless it is technically impracticable to achieve such ARARs.¹²

In addition to these two Threshold Criteria, five “Balancing Criteria” and two “Modifying Criteria” must be considered when evaluating remedial alternatives. The Balancing and Modifying Criteria are as follows:

Balancing Criteria:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness

¹⁰ “Documenting Post-ROD Changes: Minor Changes, Explanations of Significant Differences, and ROD Amendments” from EPA’s Guidance Document titled “A Guide to Preparing Superfund Proposed Plans, Records of Decision, and other Remedy Selection Decision Documents” (EPA, 1999b).

¹¹ These Federal regulations are set forth at 40 CFR Part 300, Paragraph 300.430(e)(9).

¹² ARARs for the Chemplex Site are discussed in Section 4.4.

- Implementability
- Cost

Modifying Criteria:

- State acceptance
- Community acceptance

Balancing Criteria help the further evaluation of those remedial alternatives that meet both Threshold Criteria. Modifying Criteria take into account the concerns of state regulatory agencies and the public.

Table 5-1 summarizes the comparative analysis of the three retained remedial alternatives. Tables 5-2 through 5-10 summarize the total present value (also called “present worth”) for each alternative, along with backup information and assumptions.

The detailed evaluation of the alternatives against the nine NCP criteria, shown in Table 5-1, is summarized below. For details regarding Alternative 1, or the No Further Action Alternative, see Section 4.8.1 of the FFFS.

5.2 Alternative 2: Pump and Treat

5.2.1 Threshold Criteria

As shown in Table 5-1, Alternative 2, “Pump and Treat”, does not reliably and effectively meet the two Threshold Criteria, Protectiveness and Compliance with ARARs.

5.2.1.1 Protectiveness

Alternative 2 would not be protective of human health because potential future exposure to PCE-impacted groundwater migrating downgradient would not be reliably protected against if the sole remedial approach were groundwater extraction and treatment. Complete capture of PCE-containing groundwater is made impossible by the fractured bedrock conditions. Under these conditions, neither extracting from the Chemplex groundwater recovery system at a greater flowrate nor adding more recovery wells would result in reliable VOC capture. A potential for human exposure to VOCs in groundwater would thus exist under Alternative 2.

PCE concentrations in surface waters are not anticipated to be above levels of concern for protecting potential human and ecological receptors based on the modeling performed as part of the FFFS and upon the surface water monitoring dataset.

5.2.1.2 Compliance with ARARs

This alternative would not comply with drinking water MCLs because PCE has migrated, at levels of concern, outside of the existing Point of Compliance Boundary, and as described in

Appendix D, it is technically impracticable from an engineering perspective to restore PCE concentrations outside the Point of Compliance to drinking water MCLs using pump-and-treat technology.

5.2.2 Balancing Criteria

5.2.2.1 *Long-term Effectiveness and Permanence*

Alternative 2 does not effectively, and on a long-term basis, prevent possible future migration of PCE-containing groundwater to achieve cleanup goals in the Attainment Area, due to the technical impracticability issues described in Appendix D.

5.2.2.2 *Reduction of Toxicity, Mobility, or Volume through Treatment*

Additional chemical mass beyond that provided by naturally-occurring biodegradation could be removed by extracting a portion of the PCE mass, including PCE in groundwater found close to suspected source areas, that would otherwise leave the Point of Compliance boundary and migrate downgradient. VOCs in extracted groundwater would be removed by air stripping treatment. In addition, as demonstrated during field investigations (EKI, 1998), biodegradation is occurring in the West Region, with some limited potential for biodegradation in the East Region. Furthermore, active extraction appears to interfere with the natural biodegradation processes.

5.2.2.3 *Short-term Effectiveness*

Alternative 2 is effective in the short term, as Site chemicals have not been found in private water supply wells at levels of concern (IDPH, 2011).

5.2.2.4 *Implementability*

This alternative is implementable, as the groundwater extraction and remediation system is currently mothballed as part of the Performance Test and regularly exercised to ensure operability in the event that Alternative 2 is selected.

5.2.2.5 *Cost*

As shown in Table 5-2, the total estimated present value of Alternative 2 is \$27,900,000.

5.2.3 Modifying Criteria

5.2.3.1 *State Acceptance*

Unknown.

5.2.3.2 *Community Acceptance*

A public comment period will be provided following issuance of the Proposed Plan by EPA.

5.3 Alternative 3: Exposure Control

5.3.1 Threshold Criteria

5.3.1.1 *Protectiveness*

Alternative 3 would be protective of human health by providing a municipal water source to downgradient residents for domestic use, thereby preventing potential future exposure to potentially-contaminated groundwater via domestic use. The waterline and individual residential connections to the waterline have been installed. Additional protection would be provided by monitored natural attenuation, oxidant or electron donor application, and a program of institutional controls and monitoring.

Based on a risk assessment performed as part of the FFFS, the risks to residents via the vapor intrusion scenario and the child wading in Rock Creek scenario are not expected to be significant. Based on the results of the Performance Test of this Alternative as well as modeling performed as part of the FFFS, PCE concentrations are not expected to be above levels of concern for protection of ecological receptors.

Institutional controls including a City ordinance, environmental covenants, and land owner agreements provide additional protectiveness by preventing potential residential exposure to impacted groundwater.

5.3.1.2 *Compliance with ARARs*

This alternative would comply with drinking water MCLs at downgradient residences connected to the municipal water system. Compliance with cleanup goals outside the TI zone would be assessed by monitoring along and upgradient of the proposed TI zone boundary.

ARARs would not be achieved within the TI zone. Remedial Action Objectives pertaining to protection of potential human and ecological receptors would be achieved.

5.3.2 Balancing Criteria

5.3.2.1 *Long-term Effectiveness and Permanence*

Due to extension of the municipal water system westward along 9th Street, coupled with the City well ordinance, residents connected to the municipal water system are protected against potential future exposure to PCE-containing groundwater.

5.3.2.2 *Reduction of Toxicity, Mobility, or Volume through Treatment*

PCE has been removed from Site groundwater by the OU-1 remedial system, with the removed PCE mass treated. However, the removal mass rate declined until reaching a steady state of about 2 pounds per day, indicative of mass diffusion limitations. Reduction of localized “hot spot” VOC concentrations by treatment through oxidation or electron donor addition could reduce contaminant volume. Based on monitoring results to date,

biodegradation is occurring in the West Region of the Site, with some limited potential for biodegradation in the East Region.

5.3.2.3 Short-term Effectiveness

Due to extension of the municipal water system westward along 9th Street, coupled with the City well ordinance, residents connected to the municipal water system are protected against potential future exposure to PCE-containing groundwater in the short term.

5.3.2.4 Implementability

Alternative 3 has been shown to be implementable during the two-and-a-half-year performance test of the remedy.

5.3.2.5 Cost

As shown in Tables 5-5, the estimated total present worth for Alternative 3 is \$18,600,000.

5.3.3 Modifying Criteria

5.3.3.1 State Acceptance

Unknown at this point in time.

5.3.3.2 Community Acceptance

A public comment period will be provided following issuance of the Proposed Plan by EPA.

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Table 2-1
Timeline of Correspondence with Regulatory Agencies
 Chemplex Site, Clinton, Iowa

Date	Event or Submittal
1968	Chemplex facility started operation
15 October 1984	Listing on Proposed National Priorities List ("NPL")
8 September 1987	Consent Order for Remedial Investigation/Feasibility Study ("RI/FS")
27 September 1989	First Operable Unit ("OU-1") Record of Decision Signed
28 December 1989	Second Operable Unit ("OU-2") Consent Order for RI/FS
11 February 1991	Deleted from Proposed NPL
26 July 1991	Explanation of Significant Differences ("ESD") finalized
7 November 1991	OU-1 Consent Decree for Remedial Design/Remedial Action ("RD/RA") finalized
12 May 1993	OU-2 ROD signed
2 February 1994	OU-1 Remedial Design completed
31 May 1994	OU-1 Remedial Action construction began
6 February 1995	OU-2 Consent Decree for RD/RA finalized
14 September 1995	OU-1 Preliminary Close Out Report signed
18 December 1996	OU-2 Remedial Design Completed
17 March 1998	Submittal of Natural Attenuation Investigation: Summary of August 1997 In-Situ Groundwater Sampling
29 May 1998	Submittal of Technical Memorandum Regarding Proposal to Restore Extraction Capability at Well DAC-2 using Well DAC-1 and EW-11a
11 February 1999	Submittal of Proposal for Suspension of Extraction from the Lower Hopkinton Layer
17 March 1999	Suspension of Extraction from the Lower Hopkinton Layer
9 June 1999	EPA First Five Year Review
17 April 2001	Submittal of Shutdown Criteria for Intermittently Active LGE Wells, Landfill Remediation System
15 June 2001	Submittal of Proposal for Placement of Catalytic Oxidizer into Standby Service
5 March 2002	Submittal of Revised Proposal for Placement of Catalytic Oxidizer into Standby Service
5 March 2002	Submittal of Updated Assessment of Upper-Bound Carcinogenic Risks Associated with Unabated Air Emissions
9 April 2003	OU-2 Soil Vapor Extraction system ceased operation, with EPA approval
4 June 2003	Submittal of Technical Memorandum, Reevaluation of Groundwater Remedy, Updated Assessment of Remedial Technologies for Groundwater as part of Compendium of Technical Memoranda
5 June 2003	Submittal of Results of Updated Human Health Risk Assessment for Groundwater as part of Compendium of Technical Memoranda
6 June 2003	Submittal of Results of Screening Human Health Risk Assessment for Vapor Intrusion of Chemicals for Groundwater into Indoor Air as part of Compendium of Technical Memoranda
5 September 2002	Submittal of Proposed Corrective Action Plan for East Region Extraction System Enhancements
16 September 2004	Submittal of Reevaluation of Groundwater Remedy, Updated Proposal for Revised Remedy
19 May 2005	Submittal of Proposal for Suspension of Extraction from the Farmers Creek Layer and the Landfill Wells
7 July 2005	Submittal of Transmittal of Remedial Technology Evaluation Performed to Date
8 September 2005	EPA meeting with Community Advisory Group in City of Camanche

Table 2-1
Timeline of Correspondence with Regulatory Agencies
 Chemplex Site, Clinton, Iowa

Date	Event or Submittal
7 November 2005	Suspension of Extraction from Landfill Wells LF-1 and LF-2
8 November 2005	Suspension of Extraction from Landfill Wells LF-3, LF-4, and LF-7
9 November 2005	Suspension of Extraction from Farmers Creek Extraction Wells
14 November 2005	Suspension of Extraction from Landfill Wells LF-5 and LF-6
2 December 2005	Submittal of Response to Comments regarding Transmittal of Remedial Technology Evaluation to Date
15 December 2005	EPA meeting with Community Advisory Group in City of Camanche
28 March 2006	ACC/GCC and EPA perform Rock Creek walk, including surface water and sediment sampling, with members of the Community Advisory Group
12 May 2006	Submittal of Draft Focused Feasibility Study
27 June 2006	EPA meeting with Community Advisory Group in City of Camanche
25 October 2006	EPA meeting with Community Advisory Group in City of Camanche
30 November 2006	Submittal of Draft Final Focused Feasibility Study, including response to comments on 12 May 2006 Draft Focused Feasibility Study
20 July 2007	ACC/GCC submits Final Focused Feasibility Study Report for OU-1 ("FFFS")
9 April 2008	EPA issues Statement of Additional Work ("SOAW") and conditionally approves shutting down the OU-1 groundwater extraction system as part of Performance Test of "Exposure Control" remedy, subject to completion of documents outlined in the SOAW.
April 2008	ACC/GCC performs baseline groundwater sampling.
12 July 2008	Revised OU-1 PME Plan submitted
19 September 2008	ACC/GCC submits Final Standby Plan
22 September 2008	ACC/GCC submits Final Contingency Plan for Exposure Control Pilot Test
26 September 2008	EPA approves shutdown of OU-1 groundwater extraction system and placement into long-term standby service as part of Performance Test of "Exposure Control" remedy.
29 September 2008	Performance Test of "Exposure Control" remedy begins with shutdown of OU-1 groundwater extraction system and placement into long-term standby service.
24 October 2008	ACC/GCC submits Hot Spot Pilot Test Work Plan
27 October 2008	ACC/GCC submits revised Quality Assurance Project Plan ("QAPP")
October 2008	ACC/GCC submits Health and Safety Plan Addendum
October 2008	ACC/GCC performs first post-shutdown groundwater sampling.
20 February 2009	ACC/GCC submits Institutional Control Plan
17 March 2009	ACC/GCC submits Revised Hot Spot Pilot Test Work Plan
July 2009	Hot Spot Pilot Test begins
21 December 2009	ACC/GCC submits Addendum to Institutional Control Plan
12 March 2010	ACC/GCC submits Addendum No. 1 to PME Plan
5 May 2010	ACC/GCC submits Hot Spot Pilot Test 6-Month Progress Report
20 December 2010	ACC/GCC submits Memorandum entitled "Performance Test Results and Proposed Updated Remedy"
21 December 2010	ACC/GCC submits Hot Spot Pilot Test Evaluation Report
7 April 2011	ACC/GCC submits Addendum No. 2 to PME Plan

TABLE 3-1
Mass of Volatile Organic Compounds Recovered via Groundwater Extraction
 Chemplex Site -- Clinton, Iowa

Year	Mass Removed via VOC Stream (lb)	Mass Removed via BNA Stream (lb)	Total Mass Removed (lb)
1994	-	58	58
1995	209	3,773	3,982
1996	423	3,567	3,990
1997	378	2,395	2,774
1998	325	2,075	2,401
1999	344	2,088	2,432
2000	485	2,363	2,848
2001	181	1,440	1,621
2002	246	1,405	1,651
2003	393	1,264	1,657
2004	283	1,103	1,386
2005	217	855	1,071
2006	179	638	817
2007	166	569	735
2008	131	421	552
Total	3,961	24,013	27,974

Abbreviations

lb = pounds

TABLE 4-1
Summary of Current and Proposed Groundwater Cleanup Goals
 Chemplex Site--Clinton, Iowa

Compound	Current Groundwater Cleanup Goals (ug/L) (a)	Proposed Groundwater Cleanup Goals (ug/L)	TI Waiver Proposed?
Volatile Organic Compounds			
Benzene	1	5	Yes
1,2-Dichlorobenzene	600	600	No
1,1-Dichloroethene	7	7	Yes
1,2-Dichloroethene (sum of cis and trans isomers)	70	-- (b)	Yes (b)
cis-1,2-Dichloroethene	--	70	Yes
trans-1,2-Dichloroethene	--	100	No
Ethylbenzene	700	700	No
Methylene Chloride	5	5	No (c)
Styrene	100	100	No
1,1,2,2-Tetrachloroethane	0.2	-- (d)	No
Tetrachloroethene	5	5	Yes
Toluene	2,000	1,000	No
1,1,1-Trichloroethane	200	200	No
Trichloroethene	3	5	Yes
Vinyl Chloride	0.015	2	Yes
Xylenes	10,000	10,000	No
Polynuclear Aromatic Hydrocarbons			
Benzo(a)pyrene	0.2	0.2	No (e)
Naphthalene	20	1.4 (4)	No (f)
Metals			
Antimony	3	6	No
Arsenic	0.03	10	No (g)
Barium	2,000	2,000	No

Notes:

- (a) Cleanup Standards are as shown in the Five Year Report for the Chemplex Site, dated 9 June 1999 and prepared by the Environmental Protection Agency, Region VII. The current groundwater cleanup goals were established based on Chapter 133 of the Iowa Administrative Code, which became effective in 1989. These provisions set forth a hierarchical approach to set "action levels" that, if exceeded, would require identification of the nature and extent of a release. They were not established as cleanup levels by the Iowa Department of Natural Resources. The hierarchy to select action levels was: (1) select the Lifetime Health Advisory Level ("HAL"), if one exists; (2) if no HAL exists, select the Negligible Cancer Risk Level ("NRL"); and (3) if no HAL or NRL exists, select the drinking water Maximum Contaminant Level ("MCL"). Under current regulatory practice in the State of Iowa, MCLs are now commonly applied for "protected" groundwater sources.
- (b) The Consent Decree for the Chemplex First Operable Unit, dated September 1990, set forth a Groundwater Cleanup Standard of 70 micrograms per liter (ug/L) for total 1,2-Dichloroethene (Total 1,2-DCE) based on the then-current Health Advisory Level (HAL). This standard was established for the total of the cis and trans isomers because the analytical instruments at that time could not readily separate and report the two isomers individually. Because modern instruments can report the concentration of each isomer, and because both isomers have Federal Drinking Water Maximum Contaminant Levels (MCLs), ACC/GCC is proposing a Groundwater Cleanup Goal for each isomer that is equal to its MCL. A cleanup goal for Total 1,2-DCE is thus no longer needed.
- (c) Methylene chloride has been sporadically detected in Site groundwater analyses. These detections of

TABLE 4-1
Summary of Current and Proposed Groundwater Cleanup Goals
Chemplex Site--Clinton, Iowa

methylene chloride, a common laboratory contaminant, in Chemplex groundwater are generally believed to result from laboratory contamination in view of repeated detections of this analyte in trip and field blanks collected during Site sampling events. Methylene chloride will continue to be evaluated in the Chemplex groundwater monitoring network.

- (d) 1,1,2,2-tetrachloroethane was not detected above the current cleanup standard, and therefore does not appear to be a chemical of concern at this Site; thus, it is proposed that the cleanup standard be deleted and that this analyte be deleted from the list of chemicals of concern for the Chemplex Site.
- (e) Benzo(a)pyrene is a polynuclear aromatic hydrocarbon (PAH) associated with historic releases of debutanized aromatic concentrate (DAC), a byproduct of ethylene production. As PAHs such as benzo(a)pyrene are generally less mobile in groundwater compared with volatile organic compounds (VOCs), their distribution at the Chemplex Site is not as widespread as PCE and its daughter products. Benzo(a)pyrene has been found from time to time in groundwater downgradient of the DAC management area of the polyethylene plant.
- (f) Naphthalene is a PAH associated with historic releases of DAC and potentially with wastes disposed of in the Chemplex Landfill. The 1990 Consent Decree used the HAL for naphthalene, 20 ug/L, as a surrogate for establishment of cleanup standards for a number of non-carcinogenic PAHs. The Environmental Protection Agency (EPA) has not established an MCL for naphthalene. EPA has now determined that naphthalene may be a carcinogen, and has set a concentration of 1.4 ug/L, equivalent to a risk level of one-in-one hundred thousand (10⁻⁵), as a presumptive groundwater cleanup goal. For reference, the Iowa Statewide Standard for naphthalene in Protected Groundwater is 100 ug/L, and 700 ug/L in Non-Protected Groundwater. As PAHs such as naphthalene are generally less mobile in groundwater compared with VOCs, their distribution at the Chemplex Site is not as widespread as PCE and its daughter products. Naphthalene has been found from time to time at levels below 20 ug/L but above 1.4 ug/L in groundwater immediately downgradient of the DAC management area. Naphthalene has also been occasionally detected above 1.4 ug/L in the far downgradient area of the Chemplex groundwater monitoring network. Given this analyte's limited mobility and the lack of a discernible naphthalene plume emanating from the plant area, it is not believed these far downgradient detections result from past plant operations.
- (g) Arsenic has been detected at the Chemplex Site at concentrations greater than the Proposed Groundwater Cleanup Goal. However, high background levels of arsenic are typical in Iowa. The Chemplex site is not a confirmed source of metals, including arsenic. Arsenic and other metals are no longer routinely sampled in Site groundwater.

Abbreviations:

HAL = Health Advisory Level

MCL = Maximum Contaminant Level

NRL = Negligible Risk Level

ug/L = micrograms per liter

TABLE 4-2A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>FEDERAL</u>			
<u>Safe Drinking Water Act</u>			
National Primary Drinking Water Standards	40 United States Code ("USC") Section 300; 40 Code of Federal Regulations ("CFR") Part 141	Establishes maximum contaminant levels ("MCLs"), which are standards for public water systems.	Relevant and appropriate. The MCLs for organic and inorganic contaminants are applicable to Site groundwater contaminants.
National Secondary Drinking Water Standards	40 United States Code ("USC") Section 300; 40 CFR Part 143	Establishes secondary maximum contaminant levels ("SMCLs"), which are non-enforceable guidelines for public water systems to promote the aesthetic quality of the water.	Not applicable or relevant and appropriate. The groundwater above the Maquoketa Shale layer is not used as a public water supply at the Site.
<u>Clean Water Act</u>			
Ambient Water Quality Criteria ("AWQC")	33 USC Section 1251-1376; 40 CFR Part 131, Quality Criteria for Water	Requires the states to set ambient water quality criteria ("AWQC") based on use classifications and the criteria developed under Section 304(a) of the Clean Water Act.	Applicable. AWQC have been developed for several organic and inorganic contaminants in Site groundwater. Other criteria may also be applicable.

TABLE 4-2A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL (CONTINUED)			
<u>National Pollutant Discharge Elimination System Permit Regulations</u>	33 USC Section 1251-1376; 40 CFR Parts 122 and 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Applicable. The existing groundwater recovery system would continue to operate under its existing NPDES Permit 2300108.
National Pretreatment Standards	33 USC Section 1251-1376; 40 CFR Part 403 and 414	Sets standards to control pollutants that pass through or interfere with treatment processes in Publicly-Owned Treatment Works (wastewater treatment plants) or that may contaminate sewage sludge.	Not applicable or relevant and appropriate. There will be no discharge into a POTW.
<u>Clean Air Act</u>			
National Primary and Secondary Ambient Air Quality Standards	42 USC Section 7401-7642; 40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	This is applicable if contaminants are discharged to the air during the groundwater treatment.
<u>Solid Waste Disposal Act</u>	40 CFR Part 265, Subpart AA	Establishes exhaust criteria and treatment-based influent criteria.	Subpart AA is applicable if the influent groundwater has a concentration of total organics exceeding 10 milligrams per liter ("mg/L"), and the volatile organic compounds ("VOCs") emitted from the air stripping towers exceed an annual average of 3.1 tons per year. If these conditions are met, then the tower exhaust gas must be treated.

TABLE 4-2A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE			
<u>Iowa Air Pollution Control Regulations</u>	567--Chapter 28	Ambient Air Quality Standards (Adopts 40 CFR 40).	See National Primary and Secondary Ambient Air Quality Standards. The State of Iowa does not require air permits for remediation systems.
	567--Chapter 30	This chapter pertains to emissions from on-site treatment processes.	Not applicable to on-site emission sources at the Chemplex Site. This Site is governed by 40 CFR Part 265, Subpart AA. The State of Iowa does not require air permits for remediation systems.
<u>Iowa Water Pollution Control Regulation</u>	567--Chapters 60 and 61	General definitions; water quality standards, including classification of surface waters;	Applicable to protection of water quality within the Eastern and Western Un-named Tributaries and Rock Creek.
<u>Iowa Water Pollution Control Regulation</u>	567--Chapters 62-63	Discharge of pollutants; monitoring, analytical, and reporting requirements pertaining to water disposal systems.	Applicable to protection of water quality within the Eastern and Western Un-named Tributaries and Rock Creek.
<u>Iowa Water Pollution Control Regulation</u>	567--Chapters 64	Wastewater construction and operation permits.	Not applicable or relevant and appropriate because Alternative 2 will not encompass construction or operation of a wastewater system.

TABLE 4-2A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>Iowa Responsible Parties Cleanup Regulations</u>	567--Chapter 133	These rules establish the procedures and criteria to determine the parties responsible and the cleanup actions necessary to meet the state's groundwater protection goals. These rules pertain to the cleanup of groundwater itself and to soils and surface water where groundwater may be impacted.	Applicable to pollutant concentrations in soil or groundwater above State of Iowa Action Levels.
<u>Iowa Land Recycling Program and Response Action Standards</u>	567--Chapter 137	Policies and procedures for the voluntary enrollment of contaminated property in the "land recycling program". Response action standards that participants must meet to qualify for a no further action ("NFA") certificate, and the statutory protections and immunities that are associated with the NFA.	Not an Applicable or Relevant and Appropriate Requirement, but a "To Be Considered" ("TBC") guidance standard for the State of Iowa relating to environmental covenants.

TABLE 4-2B
Potential Location-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>FEDERAL</u>			
<u>Clean Water Act</u>	33 USC Section 300; 40 CFR Part 23 Section 404	Establishes a permit program administered by the U.S. Army Corps of Engineers to regulate the nonpoint source discharges of dredged or fill material into waters of the U.S.	Not applicable or relevant and appropriate. There will not be nonpoint source discharges.
Protection of Floodplains	40 CFR Part 6.302	Establishes requirements for constructing in floodplains.	Not applicable or relevant and appropriate. There will be no floodplain construction.
Fish and Wildlife Protection	40 CFR Part 6.302	Requires actions that will control or modify a body of water be evaluated to mitigate or compensate for losses of wildlife resources.	Not applicable or relevant and appropriate. Alternative 2 will not affect wildlife resources.
Resource Conservation and Recovery Act	40 CFR 270.14(b)(11) (iii) and (iv)	Establishes building criteria for treatment, storage, and disposal ("TSD") facilities located in a floodplain.	Not applicable or relevant and appropriate. Alternative 2 will not operate a TSD facility.
<u>STATE</u>			
<u>Clean Water Act</u>	Section 401	Section 401 water quality certification is mandatory for projects requiring a Federal Section 404 permit. Section 401 certification is a state's concurrence that a project is consistent with that state's water quality standards. Also establishes criteria for wetlands.	Not applicable or relevant and appropriate. Alternative 2 will not require a Section 404 permit.

TABLE 4-2B
Potential Location-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Floodplain Development</u>	Iowa Code Section 455B, 567--Chapters 70-76	The State has authority to regulate construction within floodplains and floodways. Chapters 70-76 explain how and when a permit must be obtained for various types of development.	Not applicable or relevant and appropriate. There will be no floodplain construction.
<u>Protected Water Sources</u>	567--Chapter 53	The State has authorization to designate protected groundwater sources to restrict the movement of groundwater contaminants.	Not applicable or relevant and appropriate. A groundwater management zone was determined not to be appropriate for this site.

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>FEDERAL</u>			
<u>Solid Waste Disposal Act</u> (“SWDA”)	42 USC Section 6901-6987;		
Identification and Listing of Hazardous Wastes	42 USC Section 6901-6987; 40 CFR Part 261	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 263-265, 268 and Parts 124, 270 and 271.	Applicable. Identifies wastes considered to be hazardous. Spent granular activated carbon is generated at the Site and transported off-site every 2-3 years under manifest as F002 hazardous waste for off-site reactivation.
Standards Applicable to Generators of Hazardous Waste	42 USC Section 6901-6987; 40 CFR Part 262	Establishes standards that apply to generators of hazardous waste.	Applicable. Spent granular activated carbon is generated at the Site and transported off-site every 2-3 years under manifest as F002 hazardous waste for off-site reactivation.
Standards Applicable to Transporters of Hazardous Waste	42 USC Section 6901-6987; 40 CFR Part 263	Establishes standards that apply to transporters of hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	In the event of off-site transportation of hazardous wastes, these standards would be applicable.

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL: SWDA (CONTINUED)			
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	42 USC Section 6901-6987; 40 CFR Part 264	Establishes national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store or dispose hazardous waste.	Applicable. Hazardous wastes are managed in accordance with the Resource Conservation and Recovery Act ("RCRA").
Land Disposal Restrictions	42 USC Section 6901-6987; 40 CFR Part 268	Identifies hazardous wastes that are restricted or prohibited from land disposal.	Applicable to off-site land disposal of specific and characteristic hazardous wastes. Spent granular activated carbon, determined to be a listed waste, is managed by transportation under manifest for off-site reactivation in a furnace.
Hazardous Waste Permit Program	42 USC Section 6901-6987; 40 CFR Part 270	Covers basic EPA permitting requirements.	A permit is not required for on-site CERCLA response actions. A permit is required for off-site actions if hazardous wastes are to be managed.
<u>Occupational Safety and Health Act</u>	29 USC Section 651-678	Regulates worker health and safety.	Applicable for personnel involved in site investigations and groundwater management.

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL (CONTINUED)			
<u>Clean Air Act</u>			
National Ambient Air Quality Standards	42 USC Section 7401-7642; 40 CFR Part 50	National primary and secondary ambient air quality standards and treatment technology standards for emissions to air from: <ul style="list-style-type: none"> • incinerators • surface impoundments • waste piles • treatment units • landfills • fugitive emissions 	Applicable. The exhaust gas from the air stripping towers is governed by 40 CFR Part 265, Subpart AA.
<u>Solid Waste Disposal Act</u>	40 CFR Part 265, Subpart AA	Establishes treatment system exhaust criteria.	Subpart AA is applicable if the influent groundwater has a concentration of total organics exceeding 10 milligrams per liter ("mg/L"), and the volatile organic compounds ("VOCs") emitted from the air stripping towers exceed an annual average of 3.1 tons per year. If these conditions are met, then the tower exhaust gas must be treated.
<u>Transportation</u>			
Hazardous Materials Regulations	40 CFR Parts 171-173 and 177	Establishes requirements for transportation of hazardous materials.	Applicable to off-site transportation of hazardous materials.

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE			
<u>Iowa Solid Waste Disposal Regulations</u>	567--Chapters 100, 101, 102, 103, 110	Establishes standards for sanitary disposal projects and by regulating the disposal of solid waste through a system of general rules and specific permits. Deals with excavation of closed landfills, and the operation, cover, and monitoring of landfills.	Not applicable or relevant and appropriate to groundwater remedy.
<u>Iowa Air Pollution Control Regulation</u>	567--Chapter 23	Sets the emissions standards for contaminants and governs the release of fugitive dust in quantities creating a nuisance during site activities and emissions from a treatment system.	Not applicable (see 40 CFR Part 265, Subpart AA).
	567--Chapter 24	Applies to emissions from a permitted emission point. Could be applied to excess emissions of fugitive dust.	Not applicable (see 40 CFR Part 265, Subpart AA).
	567--Chapter 25	Governs continuous monitoring systems.	Not applicable (see 40 CFR Part 265, Subpart AA).
	567--Chapter 28	Ambient Air Quality Standards (adopts 40 CFR Part 50).	Not applicable (see 40 CFR Part 265, Subpart AA).

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Iowa Water Pollution Control Regulations</u>	567--Chapter 38	Private water well construction permits.	Applicable for the installation of private water wells for groundwater extraction.
	567--Chapter 39	Well abandonment requirements.	Applicable when monitoring or extraction wells are abandoned.
	567--Chapter 40	Water supply definitions. Defines MCLs that Chapter 133 pertains to.	Not applicable or relevant and appropriate. Alternative 2 will not affect drinking water.
	567--Chapter 49	These rules refer to nonpublic water wells, setting forth well construction standards, materials standards, and abandonment guidelines.	Applicable for the installation of private water wells for groundwater extraction.
<u>Water Withdrawals</u>	567--Chapters 50-54	These rules address water withdrawal permits. Permits are required for withdrawals greater than 25,000 gallons per day.	Applicable for the pump-and-treat alternative because extraction rates exceed 25,000 gallons per day.
	567--Chapter 82	Establishes certification requirements for well contractors.	Applicable for well drilling or abandonment. Extraction and monitoring well construction must be completed by a certified well driller.
<u>Solid Waste Management and Disposal</u>	567--Chapters 102, 103, 104, and 110	Permitting of solid waste processing and disposal facilities.	Applicable for process or disposal of solid waste.

TABLE 4-2C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 2 – Pump and Treat
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Iowa Responsible Parties Cleanup Regulations</u>	567--Chapter 133	These rules establish the procedures and criteria to determine the parties responsible and the cleanup actions necessary to meet the state's groundwater protection goals. These rules pertain to the cleanup of groundwater itself and to soils and surface water where groundwater may be impacted.	Applicable to groundwater constituents of concern in excess of State of Iowa Action Levels. Action levels are developed through MCLs or other Health-Based Standards.

TABLE 4-3A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>FEDERAL</u>			
<u>Safe Drinking Water Act</u>			
National Primary Drinking Water Standards	40 United States Code ("USC") Section 300; 40 Code of Federal Regulations ("CFR") Part 141	Establishes maximum contaminant levels ("MCLs"), which are standards for public water systems.	Relevant and appropriate. The MCLs for organic and inorganic contaminants are applicable to Site groundwater contaminants. They are applicable to the City's operation of the Camanche municipal water system.
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes secondary maximum contaminant levels ("SMCLs"), which are non-enforceable guidelines for public water systems to promote the aesthetic quality of the water.	SMCLs may be relevant and appropriate for the City's operation of the Camanche water system.
<u>Clean Water Act</u>			
Ambient Water Quality Criteria ("AWQC")	33 USC Section 1251-1376; 40 CFR Part 131, Quality Criteria for Water	Requires the states to set ambient water quality criteria ("AWQC") based on use classifications and the criteria developed under Section 304(a) of the Clean Water Act.	Applicable. AWQC have been developed for several organic and inorganic contaminants in Site groundwater. Other criteria may also be applicable.

TABLE 4-3A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL (CONTINUED)			
<u>National Pollutant Discharge Elimination System Permit Regulations</u>	33 USC Section 1251-1376; 40 CFR Parts 122 and 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Not applicable or relevant and appropriate. Alternative 3 will not discharge to waters of the United States. The existing NPDES permit will be allowed to expire.
National Pretreatment Standards	33 USC Section 1251-1376; 40 CFR Part 403 and 414	Sets standards to control pollutants that pass through or interfere with treatment processes in Publicly-Owned Treatment Works (wastewater treatment plants) or that may contaminate sewage sludge.	Not applicable or relevant and appropriate. Alternative 3 will not discharge to a POTW.
<u>Clean Air Act</u>			
National Primary and Secondary Ambient Air Quality Standards	42 USC Section 7401-7642; 40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	Not applicable or relevant and appropriate, since contaminants will not be discharged to the air.
FEDERAL (CONTINUED)			
<u>Solid Waste Disposal Act</u>	40 CFR Part 265, Subpart AA	Establishes exhaust criteria and treatment-based influent criteria.	Subpart AA is applicable if the influent groundwater has a concentration of total organics exceeding 10 milligrams per liter ("mg/L"), and the volatile organic compounds ("VOCs") emitted from the air stripping towers exceed an annual average of 3.1 tons per year. If these conditions are met, then the tower exhaust gas must be treated.
STATE			

TABLE 4-3A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>Iowa Air Pollution Control Regulations</u>	567--Chapter 28	Ambient Air Quality Standards (Adopts 40 CFR Part 50).	See 40 CFR Part 265, Subpart AA.
	567--Chapter 30	This chapter pertains to emissions from on-site treatment process.	This Site is governed by 40 CFR Part 265, Subpart AA if the groundwater treatment equipment is operating.
<u>Iowa Water Pollution Control Regulation</u>	567--Chapters 60 to 64	General definitions; water quality standards, including classification of surface waters; discharge of pollutants; and monitoring, analytical, and reporting requirements pertaining to water disposal systems.	Water quality standards for the state are applicable.

TABLE 4-3A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Iowa Responsible Parties Cleanup Regulations</u>	567--Chapter 133	These rules establish the procedures and criteria to determine the parties responsible and the cleanup actions necessary to meet the state's groundwater protection goals. These rules pertain to the cleanup of groundwater itself and to soils and surface water where groundwater may be impacted.	Applicable to pollutant concentrations in soil or groundwater above State of Iowa Action Levels.
<u>Iowa Land Recycling Program and Response Action Standards</u>	567--Chapter 137	Policies and procedures for the voluntary enrollment of contaminated property in the "land recycling program". Response action standards that participants must meet to qualify for a no further action ("NFA") certificate, and the statutory protections and immunities that are associated with the NFA.	Not an Applicable or Relevant and Appropriate Requirement, but a "To Be Considered" ("TBC") guidance standard for the State of Iowa relating to environmental covenants.

TABLE 4-3B
Potential Location-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>FEDERAL</u>			
<u>Clean Water Act</u>	33 USC Section 300; 40 CFR Part 23 Section 404	Establishes a permit program administered by the U.S. Army Corps of Engineers to regulate the nonpoint source discharges of dredged or fill material into waters of the U.S.	Not applicable or relevant and appropriate. Alternative 3 will not involve a nonpoint source discharge to waters of the U.S.
Protection of Floodplains	40 CFR Part 6.302	Establishes requirements for constructing in floodplains.	Not applicable or relevant and appropriate. There will be no construction in floodplains.
Fish and Wildlife Protection	40 CFR Part 6.302	Requires actions that will control or modify a body of water be evaluated to mitigate or compensate for losses of wildlife resources.	Not applicable or relevant and appropriate. Alternative 3 will not cause a loss to wildlife resources.
Resource Conservation and Recovery Act	40 CFR 270.14(b)(11)(iii) and (iv)	Establishes building criteria for treatment, storage, and disposal ("TSD") facilities located in a floodplain.	Not applicable or relevant and appropriate. There will be no TSD facility in a floodplain.
<u>STATE</u>			
<u>Clean Water Act</u>	Section 401	Section 401 water quality certification is mandatory for projects requiring a Federal Section 404 permit. Section 401 certification represents a state's concurrence that a project is consistent with that state's water quality standards. Also establishes criteria for wetlands.	Not applicable or relevant and appropriate. Alternative 3 will not require a Section 404 permit.
<u>Floodplain Development</u>	Iowa Code Section 455B, 567--Chapters 70-76	The State has authority to regulate construction on all floodplains and floodways in the State. Chapters 70-76 explain how and when a permit must be obtained for various types of development.	Not applicable or relevant and appropriate. Alternative 3 will not require construction in a floodplain.

TABLE 4-3B
Potential Location-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Protected Water Sources</u>	567--Chapter 53	The State has authorization to designate protected groundwater sources to restrict the movement of groundwater contaminants.	May be applicable to groundwater contaminated above State of Iowa Action Levels. However, application for a Chapter 53 designation was not approved.

TABLE 4-3C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL			
<u>Solid Waste Disposal Act (SWDA)</u>			
Identification and Listing of Hazardous Wastes	42 USC Section 6901-6987; 40 CFR Part 261	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 263-265 and Parts 124, 270 and 271.	Not applicable or relevant and appropriate.
Standards Applicable to Generators of Hazardous Waste	42 USC Section 6901-6987; 40 CFR Part 262	Establishes standards that apply to generators of hazardous waste.	Not applicable or relevant and appropriate.
Standards Applicable to Transporters of Hazardous Waste	42 USC Section 6901-6987; 40 CFR Part 263	Establishes standards that apply to transporters of hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Not applicable or relevant and appropriate.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	42 USC Section 6901-6987; 40 CFR Part 264	Establishes national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store or dispose hazardous waste.	Not applicable or relevant and appropriate.
Land Disposal Restrictions	42 USC Section 6901-6987; 40 CFR Part 268	Identifies hazardous wastes that are restricted or prohibited from land disposal.	Not applicable or relevant and appropriate.
Hazardous Waste Permit Program	42 USC Section 6901-6987; 40 CFR Part 270	Covers basic EPA permitting requirements.	Not applicable or relevant and appropriate.

TABLE 4-3C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
FEDERAL (CONTINUED)			
<u>Occupational Safety and Health Act</u>	29 USC Section 651-678	Regulates worker health and safety.	Applicable for personnel involved in site investigations and groundwater management.
<u>Clean Air Act</u>			
National Ambient Air Quality Standards	42 USC Section 7401-7642; 40 CFR Part 50	National primary and secondary ambient air quality standards and treatment technology standards for emissions to air from: <ul style="list-style-type: none"> • treatment units • landfills • fugitive emissions • incinerators • surface impoundments • waste piles 	Not applicable (see description of 40 CFR Part 265, Subpart AA under Alternative 2).
<u>Transportation</u>			
Hazardous Materials Regulations	40 CFR Parts 171-173 and 177	Establishes requirements for transportation of hazardous materials.	Applicable to transportation of hazardous materials as it relates to the injection of permanganate.
Underground Injection Control ("UIC") Program	40 CFR Part 144	Requirements and permitting for injection of materials into the subsurface.	Not an Applicable or Relevant and Appropriate Requirement, but a To be Considered ("TBC") guidance standard. Substantive requirements may be considered if injection of permanganate into the subsurface is performed under Alternative 3. A Class V UIC permit application may be required if the injection occurs offsite.

TABLE 4-3C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE			
<u>Solid Waste Disposal Act</u>	40 CFR Part 265, Subpart AA	Establishes treatment system exhaust criteria.	Not applicable or relevant and appropriate.
<u>Iowa Environmental Quality Act</u>	Chapter 455B	Defines the jurisdiction of the Department, and defines powers and duties of the Commission and the Director.	State acceptance is to be considered during evaluation of alternatives.
<u>Iowa Solid Waste Disposal Regulations</u>	567--Chapters 100, 101, 102, 103, 110	Establishes standards for sanitary disposal projects and by regulating the disposal of solid waste through a system of general rules and specific permits. Deals with excavation of closed landfills, and the operation, cover and monitoring of landfills.	Not applicable to groundwater remedy.
<u>Iowa Air Pollution Control Regulation</u>	567-- Chapter 23	Sets the emissions standards for contaminants and governs the release of fugitive dust in quantities creating a nuisance during site activities and emissions from a treatment system.	Not applicable or relevant and appropriate.
	567--Chapter 24	Applies to emissions from a permitted emission point. Could be applied to excess emissions of fugitive dust.	Not applicable or relevant and appropriate.
	567--Chapter 25	Governs continuous monitoring systems.	Not applicable (see 40 CFR Part 265, Subpart AA).
	567--Chapter 28	Ambient Air Quality Standards (Adopts 40 CFR Part 50).	Not applicable (see 40 CFR Part 265, Subpart AA).

TABLE 4-3C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
STATE (CONTINUED)			
<u>Iowa Water Pollution Control Regulations</u>	567--Chapter 38	Private water well construction permits.	Applicable for construction of new monitoring wells.
	567--Chapter 39	Well abandonment requirements.	Applicable if extraction or monitoring wells are abandoned.
	567--Chapter 40	Water supply definitions. Defines MCLs that Chapter 133 pertains to.	Not applicable or relevant and appropriate. Alternative 3 will not affect drinking water supply.
	567--Chapter 49	These rules refer to nonpublic water wells, setting forth well construction standards, materials standards, and abandonment guidelines.	May be applicable to abandonment of private wells.
<u>Water Withdrawals</u>	567--Chapters 50-54	These rules address water withdrawal permits. Permits are required for withdrawals greater than 25,000 gallons per day.	Not applicable or relevant and appropriate since groundwater extraction system will be demolished.
	567--Chapter 82	Registration of water well contractors. Established certification and requirements for well contractors	Applicable for well drilling or abandonment. Monitoring well construction must be completed by a certified well driller.
<u>Solid Waste Management and Disposal</u>	567--Chapters 102, 103, 104, and 110	Permitting of solid waste processing and disposal facilities.	Not applicable or relevant and appropriate. This is not a solid waste processing or disposal facility.

TABLE 4-3C
Potential Action-Specific Applicable or Relevant and Appropriate Requirements for
Alternative 3 – Enhanced Exposure Control
 Chemplex Site--Clinton, Iowa

Standard, Requirement, Criteria or Limitation	Citation	Description	Comment
<u>Iowa Responsible Parties Cleanup Regulations</u>	567--Chapter 133	These rules establish the procedures and criteria to determine the parties responsible and the cleanup actions necessary to meet the state's groundwater protection goals. These rules pertain to the cleanup of groundwater itself and to soils and surface water where groundwater may be impacted.	Applicable to constituents of concern in excess of State of Iowa Action Levels. Action levels are developed through MCLs or other Health-Based Standards.

TABLE 4-4
SUMMARY OF GROUNDWATER REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION
Chemplex Site--Clinton, Iowa

Component	Alternative 1 (No Further Action)	Alternative 2 (Pump and Treat)	Alternative 3 (Enhanced Exposure Control)
Institutional Controls	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Maintain existing fencing and signs around Chemplex landfill and other Second Operable Unit ("OU-2") areas Maintain existing Point of Compliance ("POC") boundary 	<ul style="list-style-type: none"> Covenants restricting construction of potable water supply wells screened above the Maquoketa Shale and providing access to the monitoring well network. Ordinance to require connection of new water services to the City municipal water system in downgradient areas where municipal water main connections are available (already implemented as part of Performance Test)
Active Remediation	<ul style="list-style-type: none"> Groundwater recovery would cease under Alternative 1 Demolish above-ground facilities and abandon in place pipelines and electrical conduits associated with the groundwater recovery system Decommission all extraction and monitoring wells 	<ul style="list-style-type: none"> Continue current operating groundwater extraction for containment purposes in accordance with the First Operable Unit ("OU-1") Consent Decree Decommission unused monitoring wells 	<ul style="list-style-type: none"> Permanently shut down the existing groundwater recovery and treatment system. Perform localized hot spot treatment as deemed appropriate based on monitoring data. Demolish above-ground facilities and abandon in place pipelines and electrical conduits associated with the groundwater recovery system Decommission extraction wells and unused monitoring wells in accordance with State well abandonment standards.
Engineering Controls	<ul style="list-style-type: none"> No engineering controls would be implemented under Alternative 1 	<ul style="list-style-type: none"> Maintain the Chemplex landfill and Second OU-2 study area vegetative covers ACC/GCC and Lyondell/Equistar to maintain existing fencing and signs around Chemplex landfill and other OU-2 areas 	<ul style="list-style-type: none"> ACC/GCC and Lyondell/Equistar to maintain existing fencing and signs around Chemplex landfill and other OU-2 areas Extend City of Camanche municipal water pipeline extension along 9th Street, 31st Avenue, and 37th Avenue; connect designated residences located potentially downgradient of groundwater plumes (already implemented as part of Performance Test). Maintain the Chemplex landfill and Second OU-2 study area vegetative covers

TABLE 4-4
SUMMARY OF GROUNDWATER REMEDIAL ALTERNATIVES FOR DETAILED EVALUATION
Chemplex Site--Clinton, Iowa

Component	Alternative 1 (No Further Action)	Alternative 2 (Pump and Treat)	Alternative 3 (Enhanced Exposure Control)
Monitoring	<ul style="list-style-type: none"> Groundwater monitoring and level gauging would be discontinued under Alternative 1 	<ul style="list-style-type: none"> Continue quarterly groundwater level gauging in accordance with the Project Monitoring Evaluation Plan ("PME Plan") Continue monitoring groundwater treatment system performance in accordance with the current National Pollutant Discharge Elimination System ("NPDES") permit Continue annual monitoring of in-situ groundwater and the Western Un-Named Tributary in accordance with the PME Plan 	<ul style="list-style-type: none"> Monitoring plan as described in Table 4-5 and PME Plan Addendum 2, including construction of new monitoring wells (now implemented as part of Performance Test). Monitor Lyondell/Equistar Production Well Nos. 1, 4, 6, and 7 every two years for VOCs
Potential Contingency Measures	<ul style="list-style-type: none"> No contingency measures are associated with Alternative 1 	<ul style="list-style-type: none"> Additional groundwater extraction wells could be constructed in the downgradient East Plume area, with the permission of affected landowners; however, such additional wells would not enable reliable groundwater capture under the fractured bedrock conditions found in this area. If surface water chemical levels exceed applicable water quality criteria, affected areas could be fenced off and warning signs posted. Localized aeration of stream segments could also be considered. 	<p>Appropriate Contingency Measures could consist of one or more of the following:</p> <ul style="list-style-type: none"> Specific contingency measures would be implemented in consultation with EPA and IDNR based on consideration of submitted monitoring data and, in certain cases, a Technical Memorandum, in accordance with the procedure described in Section 4.7.2.5. If deemed appropriate, ACC/GCC would prepare a focused feasibility study to further evaluate available data and potential responses. If VOC levels in surface water exceed applicable water quality criteria or human health risk levels, affected areas can be fenced off and warning signs posted. Localized aeration of stream segments could also be considered. Construct additional monitoring wells if VOC levels are confirmed to be elevated. Implement localized hot-spot treatment with permanganate or electron donor (pilot study has been successfully completed) Extend the City of Camanche municipal water system within the potentially downgradient area (already completed)
Technical Impracticability Zone	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Monitor existing Point of Compliance boundary. 	<ul style="list-style-type: none"> Establish a Technical Impracticability ("TI") Zone, with the approximate boundaries shown on Figure 4-2 and described in Appendix D. Within the TI Zone, chemical-specific ARARs (Applicable or Relevant and Appropriate Requirements), including drinking water primary Maximum Contaminant Levels ("MCLs"), would be waived. MCLs would still be applicable outside the TI Zone. The existing Point of Compliance boundary would no longer be in effect.

TABLE 4-5
Summary of Monitoring Plan Under Remedial Alternative 3 (3)
Chemplex Site--Clinton, Iowa

Sample Location	Stratigraphic Layer	Gauging Frequency	Sampling Frequency (VOCs)	Monitoring Zone
3	OVB	Semiannual	Semiannual	Routine Monitoring Zone
3A	OVB	Semiannual	None	-
4	OVB	Semiannual	None	-
ARC MW-1	OVB	Semiannual	None	-
ARC MW-2	OVB	Semiannual	None	-
ARC MW-8	OVB	Semiannual	None	-
ARC MW-14	OVB	Semiannual	None	-
ARC MW-200B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
ARC MW-200C	FC	Semiannual	Semiannual	Routine Monitoring Zone
ARC MW-200D	LH	Semiannual	Semiannual	Routine Monitoring Zone
ARC MW-201B	LSG	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-201C	FC	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-205B	LSG	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-205C	FC	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-205D	BL	Semiannual	Annual	Contingency Well Trigger Zone
ARC MW-206B	LSG	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-207B	LSG	Semiannual	Semiannual	Heightened Awareness Zone
ARC MW-207C	FC	Semiannual	Semiannual	Heightened Awareness Zone
ARC MW-208B	LSG	Semiannual	Annual	Heightened Awareness Zone
ARC MW-208C	FC	Semiannual	Semiannual	Heightened Awareness Zone
ARC MW-209BC	LSG/FC	Semiannual	Semiannual	Heightened Awareness Zone
ARC MW-210BC	LSG/FC	Semiannual	None	-
ARC MW-211B	LSG	Semiannual	None	-
ARC MW-211C	FC	Semiannual	Semiannual	Contingency Well Trigger Zone
ARC MW-212B	LSG	Semiannual	None	-
ARC MW-212C	FC	Semiannual	None	-
DAC-1	OVB/USG	Semiannual	None	-
DG-16	USG	Semiannual	Semiannual	Routine Monitoring Zone
DG-17B	USG	Semiannual	None	-
DG-18B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
DG-19B	USG	Semiannual	None	-
DG-21B	USG	Semiannual	Semiannual	Routine Monitoring Zone
DG-21C	LSG	Semiannual	Semiannual	Routine Monitoring Zone
EW-3a	USG	Annual	Annual	Routine Monitoring Zone
EW-6b	FC	Semiannual	None	-
EW-6c	LH	Semiannual	Semiannual	Routine Monitoring Zone
EW-7a	USG	Semiannual	Semiannual	Routine Monitoring Zone
EW-7b	FC	Annual	Annual	Routine Monitoring Zone
EW-7c	LH	Semiannual	None	-
EW-8a	USG	Semiannual	None	-
EW-10a	USG	Semiannual	None	-
EW-11a	USG	Semiannual	Semiannual	Routine Monitoring Zone
EW-11b	FC	Semiannual	Semiannual	Routine Monitoring Zone
EW-11c	LH	Semiannual	Annual	Routine Monitoring Zone
EW-13b	FC	Semiannual	Annual	Routine Monitoring Zone

TABLE 4-5
Summary of Monitoring Plan Under Remedial Alternative 3 (3)
Chemplex Site--Clinton, Iowa

Sample Location	Stratigraphic Layer	Gauging Frequency	Sampling Frequency (VOCs)	Monitoring Zone
EW-13c	LH	Semiannual	None	-
EW-14b	FC	Semiannual	Annual	Routine Monitoring Zone
EW-14c	LH	Semiannual	Semiannual	Routine Monitoring Zone
EW-15a	USG	Semiannual	None	-
EW-16c	LH	Semiannual	None	-
EW-18a	USG	Semiannual	None	-
EW-19a	USG	Semiannual	None	-
LF-2	OVB/USG	Semiannual	None	-
LF-4	OVB/USG	Semiannual	None	-
LF-6	OVB/USG	Semiannual	None	-
Munck Residence	Unknown	None	Annual	Routine Monitoring Zone
MW-4	OVB	Semiannual	None	-
MW-18B	USG	Semiannual	Annual	Routine Monitoring Zone
MW-18C	LSG	Semiannual	Annual	Routine Monitoring Zone
MW-19B	USG	Semiannual	None	-
MW-30B	USG	Semiannual	None	-
MW-53A	OVB	Semiannual	Semiannual	Routine Monitoring Zone
MW-56	FC	Semiannual	Annual	Routine Monitoring Zone
MW-56-1	USG	Semiannual	Annual	Routine Monitoring Zone
MW-57	BL	Semiannual	Annual	Routine Monitoring Zone
MW-57-1	USG	Semiannual	Semiannual	Routine Monitoring Zone
MW-58	USG	Semiannual	None	-
MW-70	BL	Semiannual	Annual	Routine Monitoring Zone
MW-73	BL	Semiannual	Semiannual	Routine Monitoring Zone
MW-73-1	FC	Semiannual	None	-
MW-73-2	LSG	Semiannual	None	-
MW-74-1	LSG	Semiannual	None	-
MW-81B	LSG	Semiannual	None	-
MW-81C	FC	Semiannual	None	-
MW-82B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-82C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-83B	LSG	Semiannual	None	-
MW-83C	FC	Semiannual	None	-
MW-85B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-85C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-85D	BL	Semiannual	None	-
MW-87A	USG	Semiannual	None	-
MW-94A	OVB	Semiannual	Annual	Routine Monitoring Zone
MW-97A	USG	Semiannual	Semiannual	Routine Monitoring Zone
MW-97B	LSG	Semiannual	None	-
MW-97C	FC	Semiannual	Annual	Routine Monitoring Zone
MW-99A	OVB	Semiannual	Semiannual	Routine Monitoring Zone
MW-102E	BL	Semiannual	None	-
MW-103B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-103C	FC	Semiannual	Semiannual	Routine Monitoring Zone

TABLE 4-5
Summary of Monitoring Plan Under Remedial Alternative 3 (3)
Chemplex Site--Clinton, Iowa

Sample Location	Stratigraphic Layer	Gauging Frequency	Sampling Frequency (VOCs)	Monitoring Zone
MW-103D	BL	Semiannual	Semiannual	Routine Monitoring Zone
MW-104B	LSG	Semiannual	Annual	Heightened Awareness Zone
MW-104C	FC	Semiannual	Annual	Heightened Awareness Zone
MW-104D	BL	Semiannual	Annual	Heightened Awareness Zone
MW-105B	LSG	Semiannual	Semiannual	Contingency Well Trigger Zone
MW-105C	FC	Semiannual	Semiannual	Contingency Well Trigger Zone
MW-105D	BL	Semiannual	None	-
MW-106A	USG	Semiannual	Semiannual	Routine Monitoring Zone
MW-106B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-106C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-107A	OVb	Semiannual	Semiannual	Routine Monitoring Zone
MW-107B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-107C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-108B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-108C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-109B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-109C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-110B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-111B	LSG	Semiannual	None	-
MW-112A	LSG	Semiannual	Annual	Routine Monitoring Zone
MW-113A	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-115A	LSG	Semiannual	None	-
MW-116A	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-117B	LSG	Semiannual	Annual	Contingency Well Trigger Zone
MW-117C	FC	Semiannual	Semiannual	Contingency Well Trigger Zone
MW-118C	FC	Semiannual	Annual	Routine Monitoring Zone
MW-119A	OVb	Semiannual	Semiannual	Expedited Contingency Zone
MW-119B	LSG	Semiannual	Semiannual	Routine Monitoring Zone
MW-119C	FC	Semiannual	Semiannual	Routine Monitoring Zone
MW-120A	OVb	Semiannual	Semiannual	Heightened Awareness Zone
MW-120B	LSG	Semiannual	Semiannual	Heightened Awareness Zone
MW-121A	OVb	Semiannual	Semiannual	Expedited Contingency Zone
MW-121B	LSG	Semiannual	Semiannual	Expedited Contingency Zone
MW-121C	FC	Semiannual	Semiannual	Expedited Contingency Zone
MW-122A	OVb	Semiannual	Semiannual	Heightened Awareness Zone
MW-122B	LSG	Semiannual	Semiannual	Heightened Awareness Zone
MW-122C	FC	Semiannual	Semiannual	Heightened Awareness Zone
MW-129A	LSG	Semiannual	Semiannual	Routine Monitoring Zone
PB-2	OVb	Semiannual	None	-
PT/RW-1	OVb	Semiannual	None	-
SW-1	-	None	Semiannual	-
SW-2	-	None	Semiannual	-
SW-3	-	None	Semiannual	-
SW-4	-	None	Semiannual	-
WELL1Q	Unknown	None	Odd Years Only	Routine Monitoring Zone

TABLE 4-5
Summary of Monitoring Plan Under Remedial Alternative 3 (3)
 Chemplex Site--Clinton, Iowa

Sample Location	Stratigraphic Layer	Gauging Frequency	Sampling Frequency (VOCs)	Monitoring Zone
WELL4Q	Unknown	None	Odd Years Only	Routine Monitoring Zone
WELL6Q	Unknown	None	Odd Years Only	Routine Monitoring Zone
WELL7Q	Unknown	None	Odd Years Only	Routine Monitoring Zone

Abbreviations:

BL = Blanding

FC = Farmers Creek

LH = Lower Hopkinton

LSG = Lower Scotch Grove

OD = Ordovician Dolomites and sandstones, located below the Maquoketa Shale layer.

OVB = Overburden

SG = Scotch Grove

USG = Upper Scotch Grove

VOCs = volatile organic compounds

Notes:

- (1) As described in the text, additional monitoring wells may be constructed based on sampling results in designated upgradient wells. If constructed, these additional monitoring wells, called "contingency wells", would be sampled semiannually for VOC analysis.
- (2) Depending on reported analytical results, ACC/GCC may petition EPA to reduce the frequency of sampling or groundwater elevation gauging at a particular well.
- (3) Sampling plan is based on Addendum 2 to the Performance Monitoring Evaluation Plan and will be revisited by EPA on an annual basis.

TABLE 4-6
Trigger Levels for Contingency Measures Under Remedial Alternative 3
 Chemplex Site -- Clinton, Iowa

Sampling Point Type and Location	Trigger Levels (ug/L) (a)				Contingency Actions if Trigger Levels Exceeded
	PCE	TCE	cis-1,2-DCE	VC	
Well located in Contingency Well Trigger Zone	10	10	140	1	Contingency Level 1 actions (b)
Well located in Heightened Awareness Zone	5	5	70	0.5	Contingency Level 2 actions (b)
Well located in Expedited Contingency Zone	5	5	70	0.5	Contingency Level 3 actions (b)
Surface water sampling location	98	80	590	25	Surface Water Contingency actions (b)

Notes:

(a) The rationale for the proposed trigger levels is described in the Contingency Plan (EKI, 2008b).

(b) See Section 4.7.2.5 for descriptions of the contingency actions.

Abbreviations:

cis-1,2-DCE = cis-1,2-Dichloroethene

MCL = Maximum Contaminant Level

ug/L = micrograms per liter

PCE = Tetrachloroethene

TCE = Trichloroethene

VC = Vinyl Chloride

TABLE 4-7
Contingency Wells to Be Constructed Under Remedial Alternative 3: Contingency Levels 1 and 2
Chemplex Site -- Clinton, Iowa

Trigger Well	Trigger Levels (ug/L) (a)				Contingency Wells to be Constructed if Trigger Levels are Confirmed to be Exceeded (a)
	PCE	TCE	cis-1,2-DCE	VC	
ARC-MW-201B	10	10	140	1	MW-124B and MW-124C
ARC-MW-201C	10	10	140	1	MW-124B and MW-124C
ARC-MW-205B	10	10	140	1	MW-124B and MW-124C
ARC-MW-205C	10	10	140	1	MW-124A, MW-124B and MW-124C
ARC-MW-205D	10	10	140	1	MW-124A, MW-124B and MW-124C
ARC-MW-206B	10	10	140	1	MW-124A, MW-124B and MW-124C
ARC-MW-208B	5	5	70	0.5	MW-125A, MW-125B, and MW-125C
ARC-MW-208C	5	5	70	0.5	MW-125A, MW-125B, and MW-125C
ARC-MW-209BC	5	5	70	0.5	MW-125A, MW-125B, and MW-125C
ARC-MW-211B	10	10	140	1	MW-128A, MW-128B, and MW-128C
ARC-MW-211C	10	10	140	1	MW-128A, MW-128B, and MW-128C
MW-104B	5	5	70	0.5	MW-128A, MW-128B, and MW-128C
MW-104C	5	5	70	0.5	MW-128A, MW-128B, and MW-128C
MW-104D	5	5	70	0.5	MW-128A, MW-128B, and MW-128C
MW-105B	10	10	140	1	MW-127A, MW-127B, and MW-127C
MW-105C	10	10	140	1	MW-127A, MW-127B, and MW-127C
MW-117B	10	10	140	1	MW-123B and MW-123C
MW-117C	10	10	140	1	MW-123B and MW-123C
MW-122A	5	5	70	0.5	MW-126A, MW-126B, and MW-126C
MW-122B	5	5	70	0.5	MW-126A, MW-126B, and MW-126C
MW-122C	5	5	70	0.5	MW-126A, MW-126B, and MW-126C

Notes:

(a) Potential Contingency Wells shown in this table are as shown on Figure 4-2.

Abbreviations:

cis-1,2-DCE = cis-1,2-Dichloroethene

TCE = Trichloroethene

VC = Vinyl Chloride

PCE = Tetrachloroethene

ug/L = micrograms per liter

TABLE 5-1
Comparative Analysis of Remedial Alternatives
Chemplex Site--Clinton, Iowa

		Alternative 1 (No Further Action)	Alternative 2 (Pump and Treat)	Alternative 3 (Exposure Control)
Threshold Criteria	Overall Protection of Human Health and the Environment	See FFFS for evaluation	Alternative 2 would not be protective of human health because potential future exposure to PCE migrating downgradient may not be manageable by groundwater recovery, as impacted groundwater cannot be fully contained due to fractured bedrock. PCE that has migrated into the rock pores is back-diffusing into groundwater and is expected to continue to do so for several centuries. Under these conditions, neither extracting at a greater flowrate nor adding more wells would result in reliable capture. PCE concentrations in surface waters are not anticipated to be above levels of concern to potential ecological receptors.	Alternative 3 would be protective of human health by providing a municipal water source to downgradient residents for domestic use, thereby preventing future exposure to potentially-contaminated groundwater via domestic use. Additional protectiveness would be provided by monitored natural attenuation, oxidant or electron donor application at localized "hot spots", and a program of institutional controls and monitoring. Based on a risk assessment performed as part of the FFFS, the risks to residents via the vapor intrusion scenario and the child wading in Rock Creek scenario are not expected to be significant. Based on the results of the Performance Test of this Alternative as well as modeling performed as part of the FFFS, PCE concentrations are not expected to be above levels of concern for protection of ecological receptors.
	Compliance with ARARs	See FFFS for evaluation	Alternative would not comply with drinking water MCLs because PCE has migrated, at levels of concern, outside of the existing Point of Compliance Boundary, and it is technically impracticable to restore PCE concentrations outside the Point of Compliance to drinking water MCLs under this Alternative.	A monitoring program would assess VOC concentrations in in-situ groundwater within a Technical Impracticability Zone. Although ARARs, including MCLs, would be waived within this zone, Remedial Action Objectives for protectiveness could be achieved.
Balancing Criteria	Long-term Effectiveness and Permanence	See FFFS for evaluation	This alternative does not effectively, and on a long-term basis, prevent possible future migration of PCE-containing groundwater to achieve cleanup goals in the Attainment Area, due to the technical impracticability issues described in Appendix D.	Due to extension of the municipal water system westward along 9th Street and promulgation of well ordinance, residents connected to the municipal water system are permanently prevented from potential future exposure to PCE-containing groundwater.
	Reduction of Toxicity, Mobility, or Volume through Treatment	See FFFS for evaluation	Additional chemical mass beyond that provided by naturally-occurring biodegradation is removed by extracting a portion of the PCE that would otherwise leave the Point of Compliance boundary and migrate downgradient. In addition, as demonstrated during the Natural Attenuation Investigation (EKI, 1998), biodegradation is occurring in the West Region of the Site, with some limited potential for biodegradation in the East Region.	Extensive mass of target compounds has been removed by the OU-1 and OU-2 remedial systems. Reduction of localized "hot spot" VOC concentrations by oxidant or electron donor addition could reduce contaminant volume. Based on monitoring results to date, biodegradation is occurring in the West Region of the Site, with some limited potential for biodegradation in the East Region.

TABLE 5-1
Comparative Analysis of Remedial Alternatives
 Chemplex Site--Clinton, Iowa

		Alternative 1 (No Further Action)	Alternative 2 (Pump and Treat)	Alternative 3 (Exposure Control)
Balancing Criteria	Short-term Effectiveness	See FFFS for evaluation	Alternative is effective in the short term, as Site chemicals are not known to have reached private residences at levels of concern.	Due to the extension of the municipal water system westward along 9th Street, coupled with the City well ordinance, residents connected to the municipal water system are protected against exposure to PCE-containing groundwater in the short term.
	Implementability	See FFFS for evaluation	Alternative has previously been implemented.	Alternative has been shown to be implementable through a performance test of the remedy.
	Cost	See FFFS for evaluation	\$27,900,000 Total Present Value.	\$18,600,000 Total Present Value.
Modifying Criteria	State Acceptance	See FFFS for evaluation	Unknown	Unknown
	Community Acceptance	See FFFS for evaluation	Unknown	Unknown

Notes:

EKI. 17 March 1998. *Natural Attenuation Investigation: Summary of August 1997 In-Situ Groundwater Sampling, First Operable Unit, Chemplex Site, Clinton, Iowa*.

Abbreviations:

MCLs = Maximum Contaminant Levels for drinking water

OU-1 = First Operable Unit for groundwater

OU-2 = Second Operable Unit for soil

TABLE 5-2
Summary of Estimated Costs of Remedial Alternatives
Chemplex Site--Clinton, Iowa

Estimated Costs	Remedial Alternative 1: No Further Action	Remedial Alternative 2: Pump and Treat	Remedial Alternative 3: Enhanced Exposure Control
Total Capital Costs (from 2010 through 2039)	\$1,900,000	\$0	\$8,000,000
Total Annual Costs (from 2010 through 2039)	\$0	\$51,900,000	\$19,700,000
Total Cost (from 2010 through 2039)	\$1,900,000	\$51,900,000	\$27,700,000
Total Present Value Cost	\$1,900,000	\$27,900,000	\$18,600,000

Notes:

1. The information in this cost estimate summary table is based on available information and on assumptions made as compiled in Tables 5-3 through 5-10. For backup information on Alternative 1, "No Further Action", refer to the *Final Focused Feasibility Study*, prepared by Erler & Kalinowski, Inc. on behalf of ACC/GCC and dated July 2007.
2. Estimated costs are expressed in 2010 dollars.
3. Present Values are calculated using an Equivalent Uniform Annual Interest Rate of 5 percent.

TABLE 5-3
Summary of Estimated Costs for Remedial Alternative 2:
Pump and Treat
Chemplex Site--Clinton, Iowa

Year	Estimated Costs			
	Capital Costs	Annual Costs	Total Cost	Total Present Value
2010	\$0	\$1,730,000	\$1,730,000	\$1,730,000
2011	\$0	\$1,730,000	\$1,730,000	\$1,648,000
2012	\$0	\$1,730,000	\$1,730,000	\$1,569,000
2013	\$0	\$1,730,000	\$1,730,000	\$1,494,000
2014	\$0	\$1,730,000	\$1,730,000	\$1,423,000
2015	\$0	\$1,730,000	\$1,730,000	\$1,356,000
2016	\$0	\$1,730,000	\$1,730,000	\$1,291,000
2017	\$0	\$1,730,000	\$1,730,000	\$1,229,000
2018	\$0	\$1,730,000	\$1,730,000	\$1,171,000
2019	\$0	\$1,730,000	\$1,730,000	\$1,115,000
2020	\$0	\$1,730,000	\$1,730,000	\$1,062,000
2021	\$0	\$1,730,000	\$1,730,000	\$1,011,000
2022	\$0	\$1,730,000	\$1,730,000	\$963,000
2023	\$0	\$1,730,000	\$1,730,000	\$917,000
2024	\$0	\$1,730,000	\$1,730,000	\$874,000
2025	\$0	\$1,730,000	\$1,730,000	\$832,000
2026	\$0	\$1,730,000	\$1,730,000	\$793,000
2027	\$0	\$1,730,000	\$1,730,000	\$755,000
2028	\$0	\$1,730,000	\$1,730,000	\$719,000
2029	\$0	\$1,730,000	\$1,730,000	\$685,000
2030	\$0	\$1,730,000	\$1,730,000	\$652,000
2031	\$0	\$1,730,000	\$1,730,000	\$621,000
2032	\$0	\$1,730,000	\$1,730,000	\$591,000
2033	\$0	\$1,730,000	\$1,730,000	\$563,000
2034	\$0	\$1,730,000	\$1,730,000	\$536,000
2035	\$0	\$1,730,000	\$1,730,000	\$511,000
2036	\$0	\$1,730,000	\$1,730,000	\$487,000
2037	\$0	\$1,730,000	\$1,730,000	\$463,000
2038	\$0	\$1,730,000	\$1,730,000	\$441,000
2039	\$0	\$1,730,000	\$1,730,000	\$420,000
Total	\$0	\$51,900,000	\$51,900,000	\$27,900,000

Notes:

1. The information in this is based on available information from operation of the Chemplex Groundwater Remediation System prior to the commencement of standby service in September 2008.
2. Estimated costs are expressed in 2010 dollars.
3. Present Values are calculated using an Equivalent Uniform Annual Interest Rate of 5 percent.
4. Amounts shown in this table are taken from Table 5-4.

TABLE 5-4
Summary of Estimated Annual Costs for Remedial Alternative 2: Pump and Treat
Chemplex Site--Clinton, Iowa

Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>ANNUAL COSTS</u>				
● Monitoring				
Gauging, sampling, and reporting				
● Conduct quarterly groundwater elevation gauging	\$8,000	qtr	4	\$32,000
● Conduct annual groundwater sampling	\$35,000	yr	1	\$35,000
● Analyze water samples for volatile organic compounds	\$30,000	yr	1	\$30,000
● Prepare data validation report	\$10,000	each	1	\$10,000
● Prepare quarterly monitoring reports	\$5,000	qtr	4	\$20,000
● Prepare annual sampling monitoring report	\$20,000	each	1	\$20,000
				<u>\$147,000</u>
● Active Remediation				
Pump and treat groundwater				
● Annual operations cost for treatment system (incl. utilities)	\$40,000	mo	12	\$480,000
● Replacement of GAC (every 24 months)	\$20,000	yr	0.50	\$10,000
● Non-routine maintenance for treatment system	\$30,000	yr	1	\$30,000
● Annual reserve for extensive rehabilitation every 15 years	\$60,000	yr	1	\$60,000
● Annual biofouling control	\$300,000	yr	1	\$300,000
● Replacement of extraction well (once every two years)	\$150,000	each	0.5	\$75,000
● Quarterly NPDES sampling and analysis	\$5,000	qtr	4	\$20,000
● NPDES permit renewal (once every five years)	\$15,000	yr	0.2	\$3,000
				<u>\$978,000</u>
● Miscellaneous				
● Prepare CERCLA 5-Year Review (once every 5 years)	\$40,000	yr	0.2	\$8,000
● Farm maintenance and OU-2 areas, including landfill cover	\$20,000	yr	1	\$20,000
● Legal and consultant support	\$20,000	mo	12	\$240,000
● EPA and IDNR oversight	\$50,000	yr	1	\$50,000
				<u>\$318,000</u>
<i>Subtotal Estimated Cost</i>				<i>\$1,443,000</i>
<i>Contingencies (assumed to be 20 percent of Subtotal Estimated Cost)</i>				<i>\$288,600</i>
<i>Total Estimated Annual Cost (in 2010 dollars)</i>				<i>\$1,730,000</i>

Notes:

1. The information in this cost estimate summary table is based on available information from operation prior to placement into standby service in September 2008.
2. Estimated costs are expressed in 2010 dollars.

TABLE 5-5
Summary of Estimated Costs for Remedial Alternative 3:
Enhanced Exposure Control
Chemplex Site--Clinton, Iowa

Year	Preliminary Estimated Costs			
	Capital Costs	Annual Costs	Total Cost	Total Present Value
2010	\$5,965,000	\$763,000	\$6,728,000	\$6,728,000
2011	\$0	\$990,000	\$990,000	\$943,000
2012	\$2,050,000	\$640,000	\$2,690,000	\$2,440,000
2013	\$0	\$640,000	\$640,000	\$553,000
2014	\$0	\$640,000	\$640,000	\$527,000
2015	\$0	\$640,000	\$640,000	\$501,000
2016	\$0	\$640,000	\$640,000	\$478,000
2017	\$0	\$640,000	\$640,000	\$455,000
2018	\$0	\$640,000	\$640,000	\$433,000
2019	\$0	\$640,000	\$640,000	\$413,000
2020	\$0	\$640,000	\$640,000	\$393,000
2021	\$0	\$640,000	\$640,000	\$374,000
2022	\$0	\$640,000	\$640,000	\$356,000
2023	\$0	\$640,000	\$640,000	\$339,000
2024	\$0	\$640,000	\$640,000	\$323,000
2025	\$0	\$640,000	\$640,000	\$308,000
2026	\$0	\$640,000	\$640,000	\$293,000
2027	\$0	\$640,000	\$640,000	\$279,000
2028	\$0	\$640,000	\$640,000	\$266,000
2029	\$0	\$640,000	\$640,000	\$253,000
2030	\$0	\$640,000	\$640,000	\$241,000
2031	\$0	\$640,000	\$640,000	\$230,000
2032	\$0	\$640,000	\$640,000	\$219,000
2033	\$0	\$640,000	\$640,000	\$208,000
2034	\$0	\$640,000	\$640,000	\$198,000
2035	\$0	\$640,000	\$640,000	\$189,000
2036	\$0	\$640,000	\$640,000	\$180,000
2037	\$0	\$640,000	\$640,000	\$171,000
2038	\$0	\$640,000	\$640,000	\$163,000
2039	\$0	\$640,000	\$640,000	\$155,000
Total	\$8,000,000	\$19,700,000	\$27,700,000	\$18,600,000

Notes:

1. The information in this cost estimate summary table is based on available information regarding past costs and assumption pertaining to future outlays shown in the following tables.
2. Estimated costs are expressed in 2010 dollars.
3. Present Values are calculated using an Equivalent Uniform Annual Interest Rate of 5 percent.
4. Amounts shown in this table are taken from Tables 5-6 through 5-10.

Chemplex Site--Clinton, Iowa

Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>CAPITAL COSTS</u>				
● Institutional Controls To Reduce Exposure				
● Legal support of environmental covenants	\$40,000	ls	1	\$40,000
				<u>\$40,000</u>
● Engineering Controls To Reduce Exposure				
New Water Line Construction and Services During Construction				
● Total cost of water line and water tower, incl. services during construction	\$5,200,000	ls	1	\$5,200,000
● Water installation consultant support	\$50,000	ls	1	\$50,000
Residential Well Abandonments				
● Consultant cost for abandonments, including reporting	\$75,000	ls	1	\$75,000
● Payments to residents to cover water bill costs and other fees	\$220,000	ls	1	\$220,000
Hot-Spot Treatment				
● Injection and reporting costs	\$160,000	ls	1	\$160,000
● Analytical costs	\$20,000	ls	1	\$20,000
				<u>\$5,725,000</u>
● Monitoring System Expansion				
Additional Monitoring Wells				
● Well construction	\$200,000	ls	1	\$200,000
				<u>\$200,000</u>
<i>Total Estimated Capital Cost (in 2010 dollars)</i>				<i>\$5,965,000</i>

Notes:

1. The information in this cost estimate summary table is based on costs incurred in 2010.
2. Costs are expressed in 2010 dollars.

TABLE 5-7
Summary of Estimated Capital Costs for Remedial Alternative 3: Enhanced Exposure Control - 2012
Chemplex Site--Clinton, Iowa

Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>CAPITAL COSTS</u>				
● Demolish Existing Below-Ground Facilities				
● Mobilize well abandonment contractor	\$10,000	ls	1	\$10,000
● Locate wells for abandonment	\$2,000	day	4	\$8,000
● Abandon extraction wells (grout in place)	\$6,000	each	39	\$234,000
● Abandon monitoring wells (grout in place)	\$1,000	each	358	\$358,000
● Convert extraction wells to monitoring well	\$6,000	each	8	\$48,000
● Permit for demolition	\$15,000	ls	1	\$15,000
				\$673,000
● Demolish Existing Above-Ground Facilities				
● Mobilize demolition contractor equipment and supplies to site	\$10,000	ls	1	\$10,000
● Demolish and remove Blower Building and equipment (keep foundation)	\$80,000	ls	1	\$80,000
● Demolish and remove lift stations and transformers; fill sumps	\$18,000	each	5	\$90,000
● Pressure wash Treatment Building equipment and decon tanks	\$75,000	ls	1	\$75,000
● Scrap and Dispose of treatment system -- GAC units	\$40,000	ls	1	\$40,000
● Scrap and Dispose of treatment system -- air strippers and CatOx	\$60,000	ls	1	\$60,000
● Scrap and Dispose of treatment system -- tanks	\$50,000	ls	1	\$50,000
● Scrap and Dispose of treatment system -- misc. eqt. and elec.	\$80,000	ls	1	\$80,000
● Scrap and Demolish and Remove Treatment Building (keep slab, fill sum)	\$250,000	ls	1	\$250,000
● Transport and dispose of non-hazardous waste	\$150	ton	80	\$12,000
				\$747,000
● Design And Construction Management Services				
● Design Services	\$75,000	ls	1	\$75,000
● Services during demolition	\$75,000	ls	1	\$75,000
				\$150,000
● Hot-Spot Injection				
● Construct injection well	\$100,000	ls	1	\$100,000
● Perform injection, including monitoring	\$40,000	ls	1	\$40,000
				\$140,000
<i>Subtotal Estimated Cost (with contractor overhead and profit)</i>				<i>\$1,710,000</i>
<i>Contingencies (assumed to be 20 percent of Subtotal Estimated Cost)</i>				<i>\$342,000</i>
<i>Total Estimated Capital Cost (in 2010 dollars)</i>				<i>\$2,050,000</i>

Notes:

1. The information in this cost estimate summary table is preliminary and conceptual pending development of detailed contract documents.
2. Estimated costs are expressed in 2010 dollars.

TABLE 5-8
Summary of Estimated Annual Costs for Remedial Alternative 3:
Enhanced Exposure Control - 2010
Chemplex Site--Clinton, Iowa

Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>ANNUAL COSTS</u>				
<ul style="list-style-type: none"> ● Monitoring 				
Gauging and sampling				
• Semiannual sampling and gauging events -- sampling	\$52,000	event	2	\$104,000
• Semiannual sampling events -- laboratory	\$12,000	event	2	\$24,000
• Supplemental sampling event -- sampling	\$20,000	each	1	\$20,000
• Supplemental sampling event -- laboratory	\$5,000	each	1	\$5,000
• Prepare data validation report	\$10,000	each	1	\$10,000
• Prepare quarterly monitoring reports	\$5,000	qtr	4	\$20,000
• Prepare sampling reports	\$30,000	yr	1	\$30,000
				<u>\$213,000</u>
<ul style="list-style-type: none"> ● Groundwater Recovery and Treatment System during Mothball Period 				
Maintain equipment in workable condition during mothball period				
• Routine maintenance	\$8,000	month	12	\$96,000
• Equipment and utilities	\$7,000	month	12	\$84,000
				<u>\$180,000</u>
<ul style="list-style-type: none"> ● Miscellaneous 				
• Legal and consultant support	\$20,000	mo	12	\$240,000
• EPA and IDNR oversight	\$130,000	yr	1	\$130,000
				<u>\$370,000</u>
<u>Total Preliminary Estimated Annual Cost (in 2010 dollars)</u>				<u>\$763,000</u>

Notes:

1. The information in this table is based on costs incurred in 2010.
2. Costs are expressed in 2010 dollars.

TABLE 5-9
Summary of Estimated Annual Costs for Remedial Alternative 3:
Enhanced Exposure Control - 2011
Chemplex Site--Clinton, Iowa

Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>ANNUAL COSTS</u>				
● Monitoring				
Gauging and sampling				
● Semiannual sampling and gauging events -- sampling	\$52,000	event	2	\$104,000
● Semiannual sampling events -- laboratory	\$12,000	event	2	\$24,000
● Prepare data validation report	\$10,000	each	1	\$10,000
● Prepare quarterly monitoring reports	\$5,000	qtr	4	\$20,000
● Prepare sampling reports	\$15,000	yr	2	\$30,000
				\$188,000
● Groundwater Recovery and Treatment System during Mothball Period				
Maintain equipment in workable condition during mothball period				
● Routine maintenance	\$8,000	month	12	\$96,000
● Equipment and utilities	\$4,000	month	12	\$48,000
				\$144,000
● Miscellaneous				
● Remedy revision reports	\$100,000	ls	1	\$100,000
● Legal and consultant support	\$20,000	mo	12	\$240,000
● EPA and IDNR oversight	\$150,000	yr	1	\$150,000
				\$490,000
<i>Subtotal Estimated Cost (with contractor overhead and profit)</i>				<i>\$822,000</i>
<i>Contingencies (assumed to be 20 percent of Subtotal Estimated Cost)</i>				<i>\$164,400</i>
<i>Total Estimated Annual Cost (in 2010 dollars)</i>				<i>\$990,000</i>

Notes:

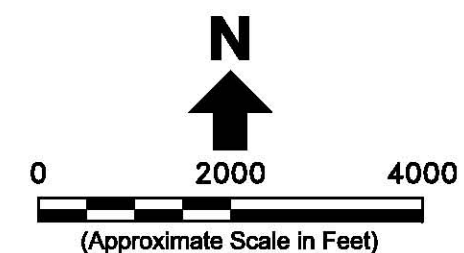
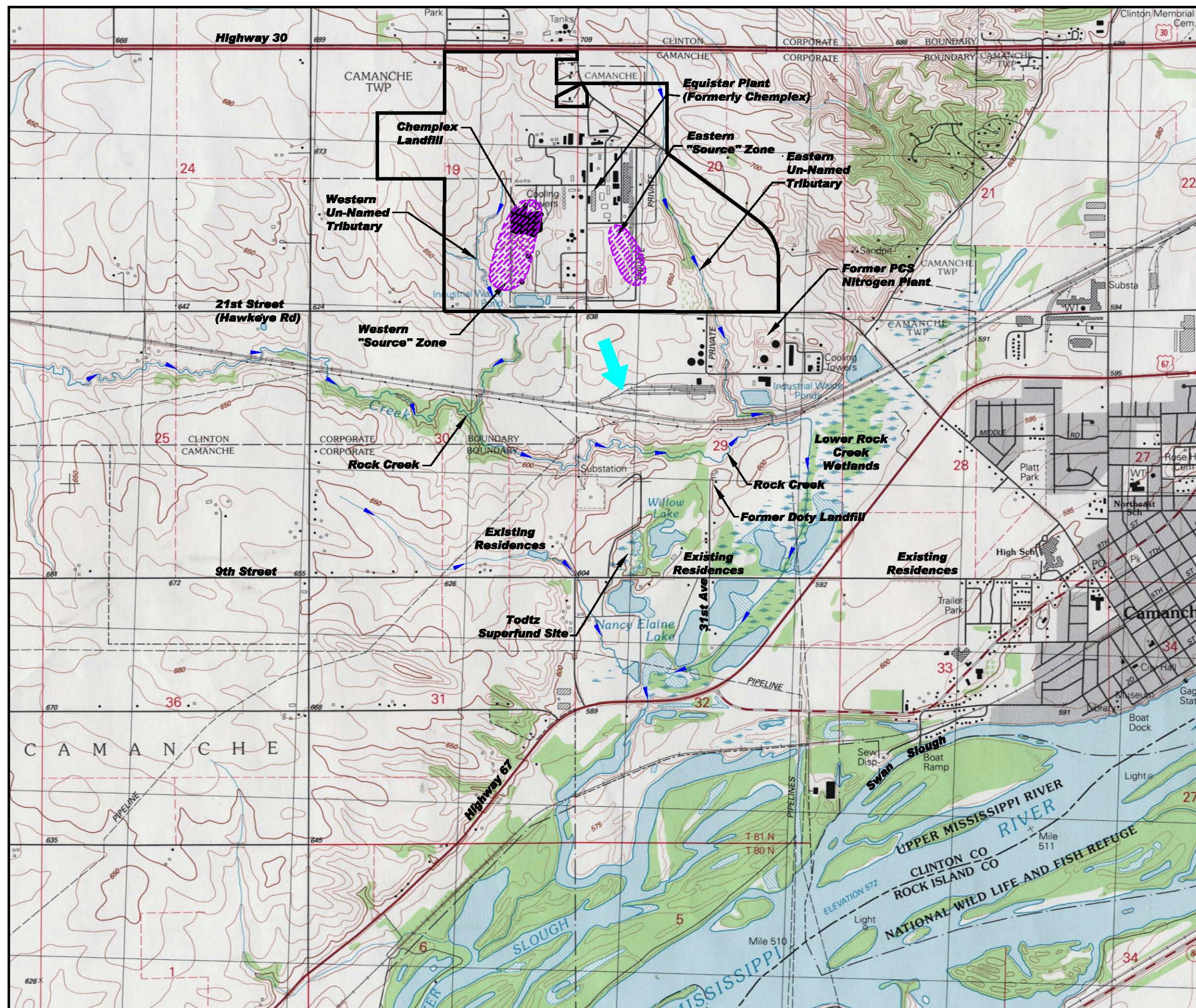
1. The information in this table is based on costs incurred to date in 2011 plus anticipated expenditures for the remainder of the year.
2. Estimated costs are expressed in 2010 dollars.

TABLE 5-10
Summary of Estimated Annual Costs for Remedial Alternative 3:
Enhanced Exposure Control - 2012 through 2039
Chemplex Site--Clinton, Iowa





Task Description	Estimated Costs			
	Unit Cost	Unit	Quantity	Subtotal
<u>ANNUAL COSTS</u>				
● Monitoring				
Gauging and sampling				
● Semiannual sampling and gauging events -- sampling	\$52,000	event	2	\$104,000
● Semiannual sampling events -- laboratory	\$12,000	event	2	\$24,000
● Prepare data validation report	\$10,000	each	1	\$10,000
● Prepare quarterly monitoring reports	\$5,000	qtr	4	\$20,000
● Prepare sampling reports	\$30,000	yr	1	\$30,000
				<u>\$188,000</u>
● Miscellaneous				
● Prepare CERCLA 5-Year Review (once every 5 years)	\$40,000	yr	0.2	\$8,000
● Legal and consultant support	\$10,000	mo	12	\$120,000
● EPA and IDNR oversight	\$40,000	yr	1	\$40,000
● Allowance for other contingency measures (see Note 2)	\$15,000	ls	12	\$180,000
				<u>\$348,000</u>
<i>Subtotal Estimated Cost (with contractor overhead and profit)</i>				<u>\$536,000</u>
<i>Contingencies (assumed to be 20 percent of Subtotal Estimated Cost)</i>				<u>\$107,200</u>
<i>Total Preliminary Estimated Annual Cost (in 2010 dollars)</i>				<u>\$640,000</u>

Notes:

1. Preliminary estimated costs are expressed in 2010 dollars.
2. "Other contingency measures" could include hot spot treatment and associated monitoring; other additional monitoring; or additional evaluations and reporting.



Legend:

-  Approximate Chemplex Site Boundary
-  Assumed General Groundwater Gradient Direction
-  Creek Flow Direction
-  Estimated Source Zone

Notes:

1. All locations are approximate.
2. Basemap source: USGS 7.5 minute series topographic map, Camanche Quadrangle, Iowa-Illinois, 1991.

Erler & Kalinowski, Inc.

Chemplex Site and Vicinity Map

Chemplex Site
Clinton, Iowa
November 2011
EKI 890052.67
Figure 2-1

West

East

4th Street

Eastern Un-named Tributary

Overburden

Upper Scotch Grove

Lower Scotch Grove

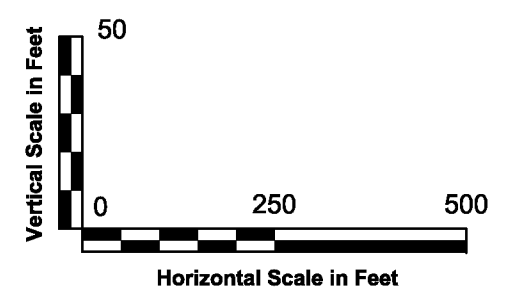
Picture Rock

Farmers Creek

Lower Hopkinton

Blanding

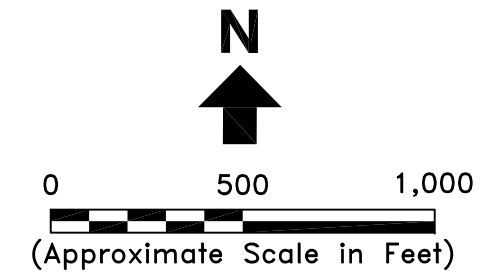
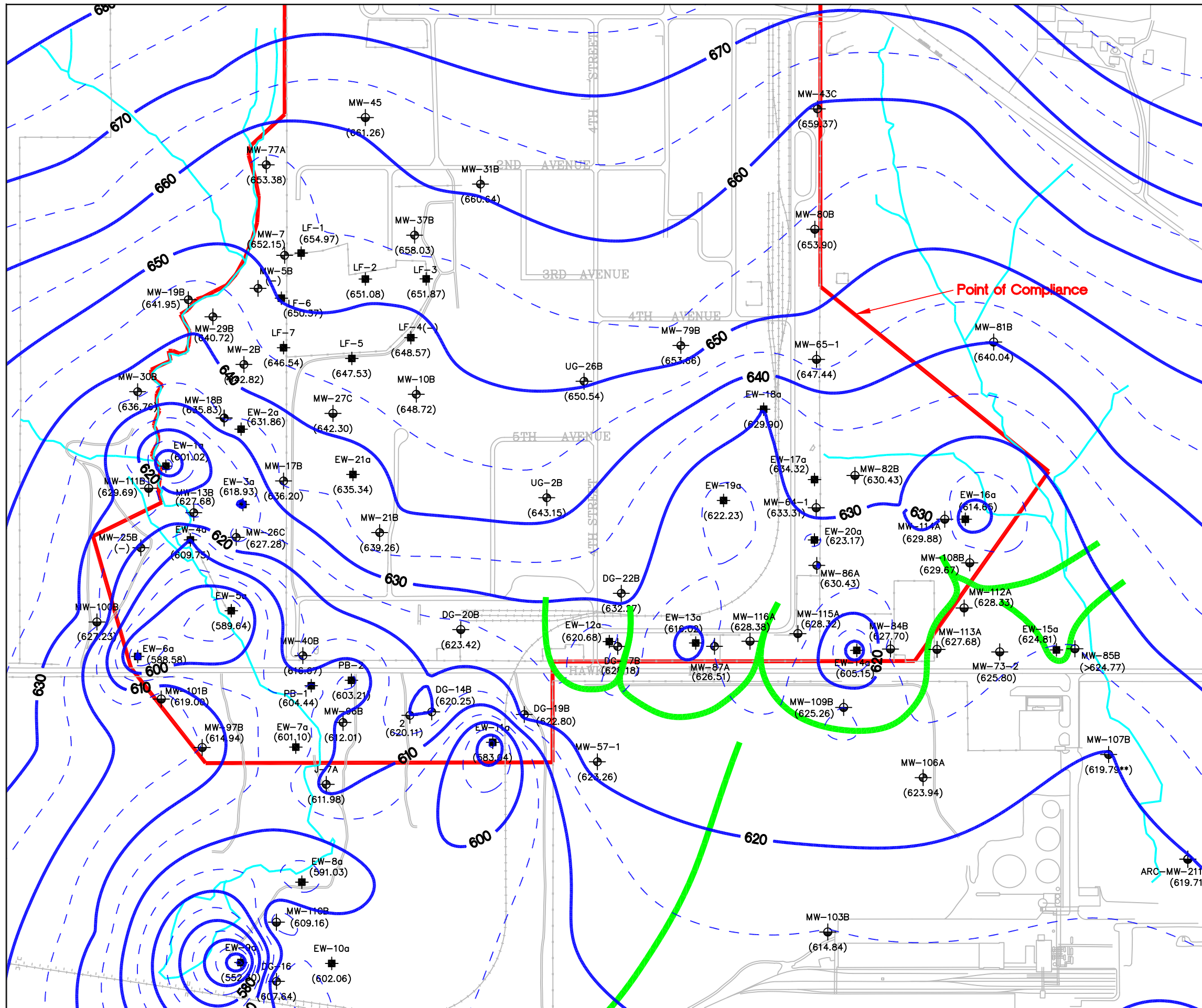
Maquoketa Shale



**Erler &
Kalinowski, Inc.**

West-East Schematic Cross Section
Near Hawkeye Road
Showing Bedrock Stratigraphy

Chemplex
Clinton, IA
November 2011
EKI 890052.67
Figure 3-1



- ★ Upper Scotch Grove Extraction Well
- ⊕ Overburden Monitoring Well
- ⊙ Upper Scotch Grove Monitoring Well
- ⊕ Lower Scotch Grove or Picture Rock Monitoring Well

- 660 — Groundwater Elevation Contour in Feet Above Mean Sea Level
- (637.65) Groundwater Elevation in Feet Above Mean Sea Level, Measured in Wells 14 April 2008
- U — Estimated Extent of Capture Zone
- — Point of Compliance

Notes:

All locations are approximate.

Contour Interval: 5 feet

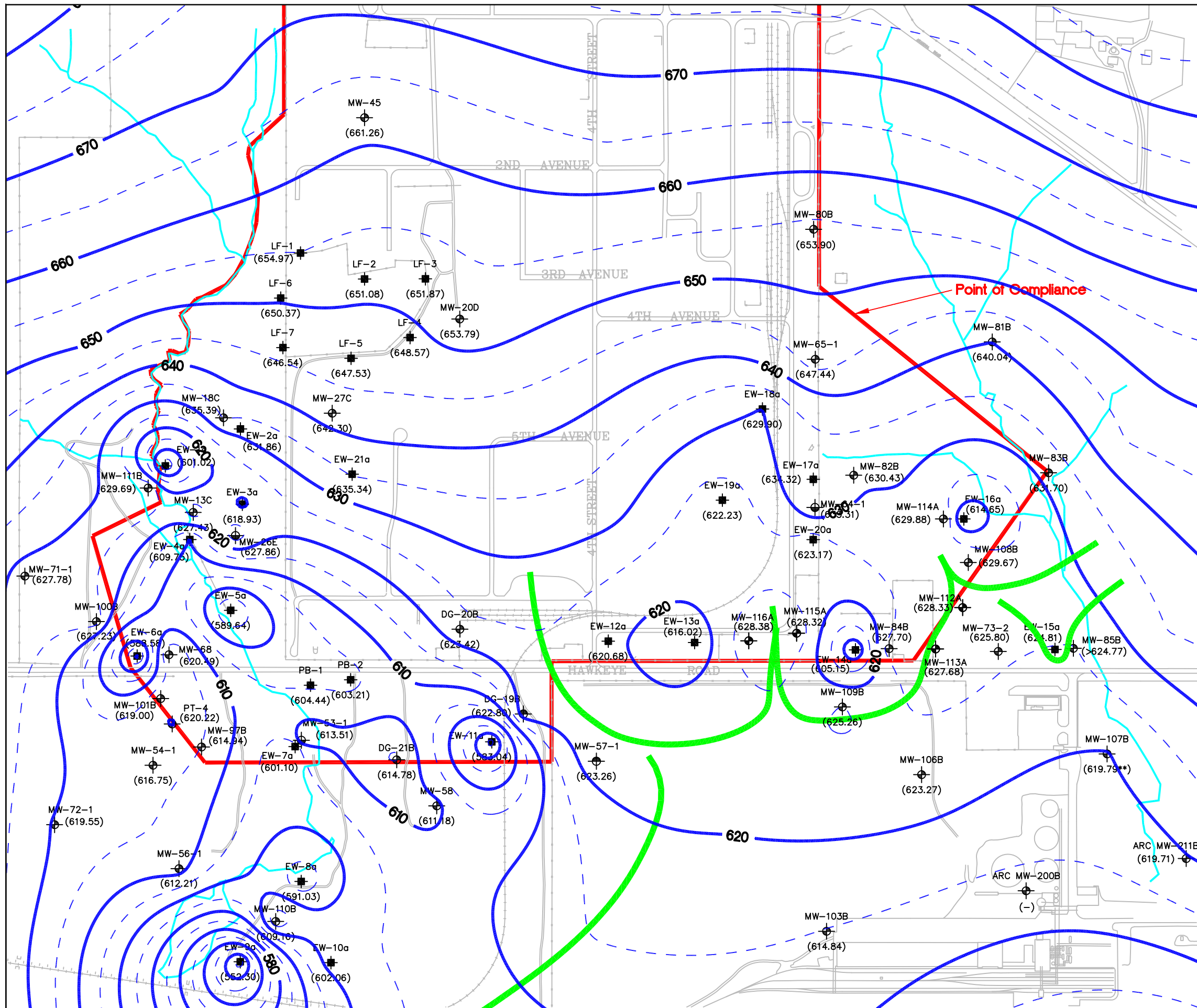
Some wells displayed are screened in underlying or overlying formations, as indicated by the well symbols.

Groundwater elevations marked with a greater than sign (>) were artesian or flowing artesian on the date of measurement.

Erler &
Kalinowski, Inc.

Upper Scotch Grove Formation
April 2008 Potentiometric Surface

Chemplex Site, First OU
Clinton, IA
November 2011
EKI 890052.67
Figure 3-2



N

0 500 1,000

(Approximate Scale in Feet)

- ★ Upper Scotch Grove Extraction Well
- ⊕ Lower Scotch Grove Monitoring Well
- ⊕ Picture Rock Monitoring Well

- 660 Groundwater Elevation Contour in Feet Above Mean Sea Level
- (637.65) Groundwater Elevation in Feet Above Mean Sea Level, Measured in Wells 14 April 2008
- U Estimated Extent of Capture Zone
- Point of Compliance

Notes:

All locations are approximate.

Contour Interval: 5 feet

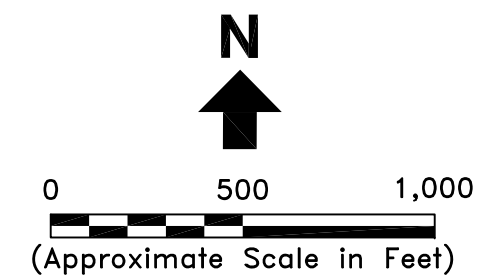
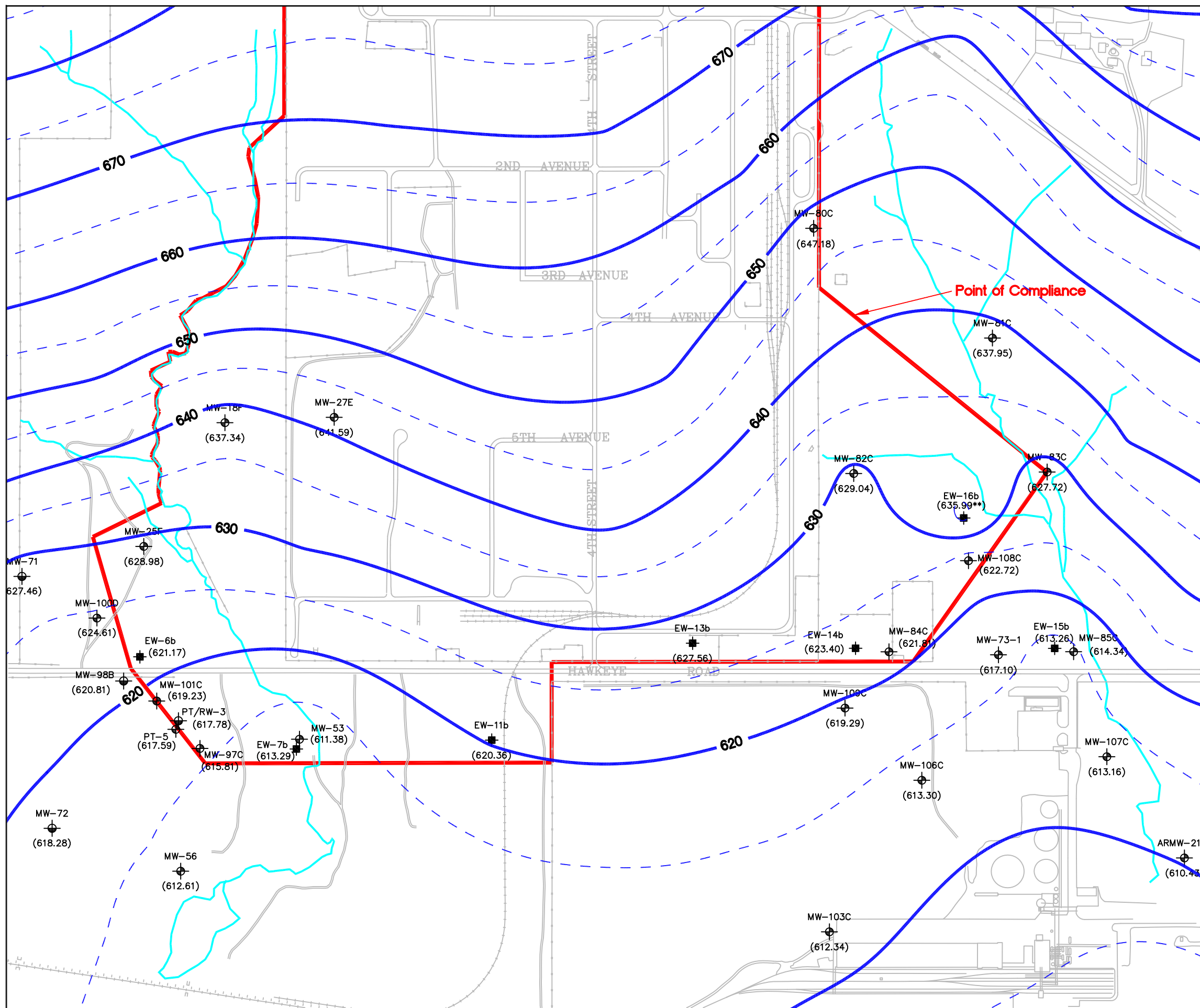
Some wells displayed are screened in underlying or overlying formations, as indicated by the well symbols.

Groundwater elevations marked with a greater than sign (>) were artesian or flowing artesian on the date of measurement.

Erler &
Kalinowski, Inc.

Lower Scotch Grove Formation
April 2008 Potentiometric Surface

Chemplex Site, First OU
Clinton, IA
November 2011
EKI 890052.67
Figure 3-3



- Farmers Creek Extraction Well
- ⊕ Farmers Creek Monitoring Well
- ⊕ Lower Hopkinton Monitoring Well

- 660 Groundwater Elevation Contour in Feet Above Mean Sea Level
- (637.65) Groundwater Elevation in Feet Above Mean Sea Level, Measured in Wells 14 April 2008
- Point of Compliance

Notes:

All locations are approximate.

Contour Interval: 5 feet

On 11 November 2005, groundwater extraction in the Farmers Creek Unit was discontinued.

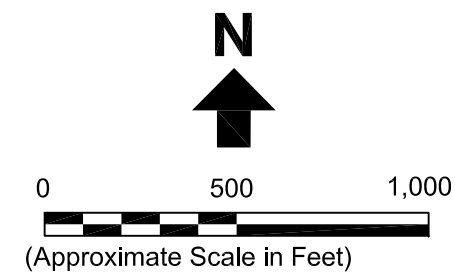
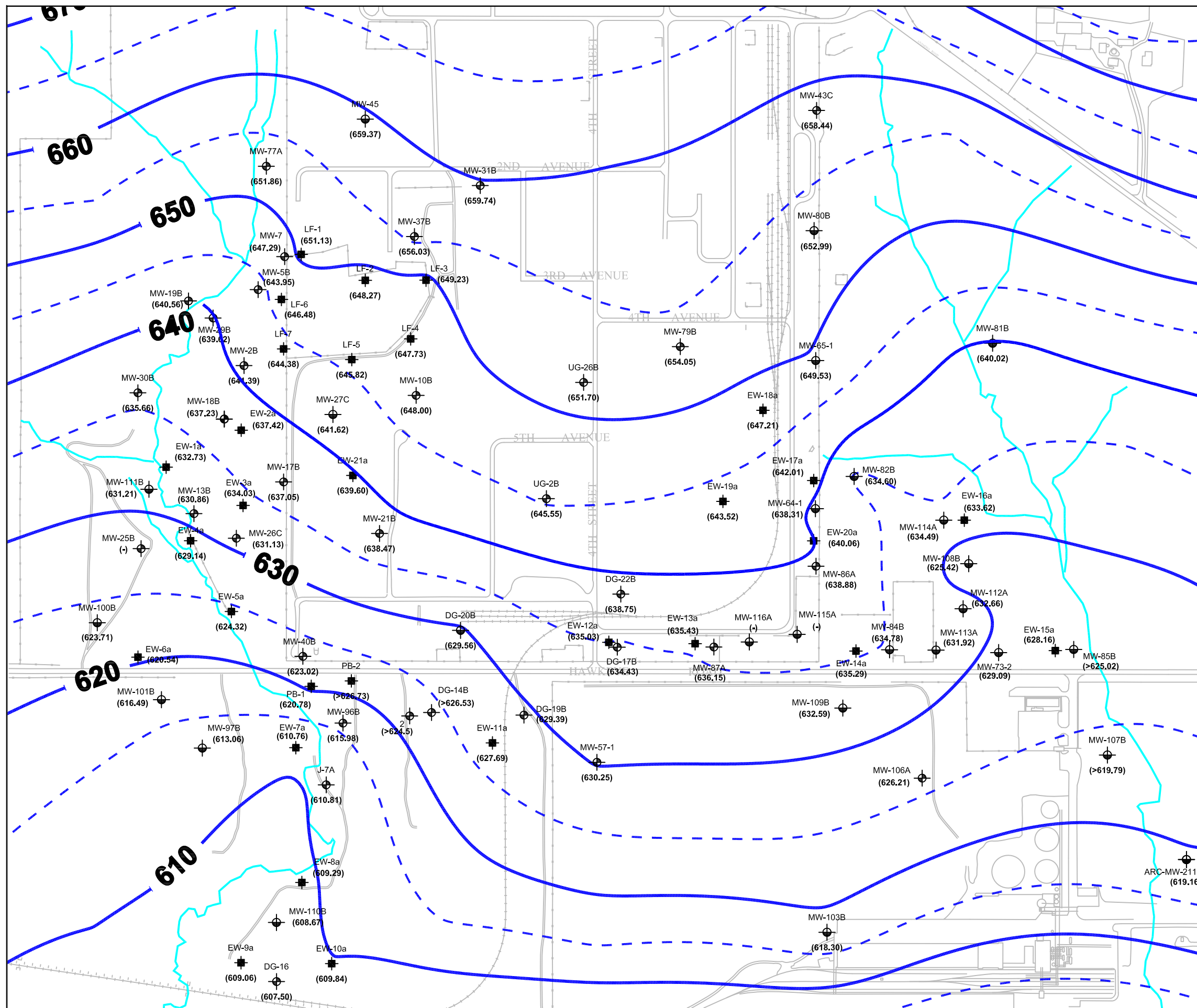
Some wells displayed are screened in underlying or overlying formations, as indicated by the well symbols.

Groundwater elevations marked with a greater than sign (>) were artesian or flowing artesian on the date of measurement.

Erler & Kalinowski, Inc.

Farmers Creek Unit
April 2008 Potentiometric Surface

Chemplex Site, First OU
Clinton, IA
November 2011
EKI 890052.67
Figure 3-4



- Upper Scotch Grove Extraction Well
- Overburden Monitoring Well
- Upper Scotch Grove Monitoring Well
- Lower Scotch Grove or Picture Rock Monitoring Well

660 Groundwater Elevation Contour
in Feet Above Mean Sea Level

(637.65) Groundwater Elevation in Feet
Above Mean Sea Level, Measured
in Wells on 10 May 2010

Notes:

All locations are approximate.

Groundwater elevation data marked with an asterisk (*) were considered possibly in error and were not used for contouring.

Contour Interval: 5 feet

On 29 September 2008, groundwater extraction in the Upper Scotch Grove Unit was discontinued.

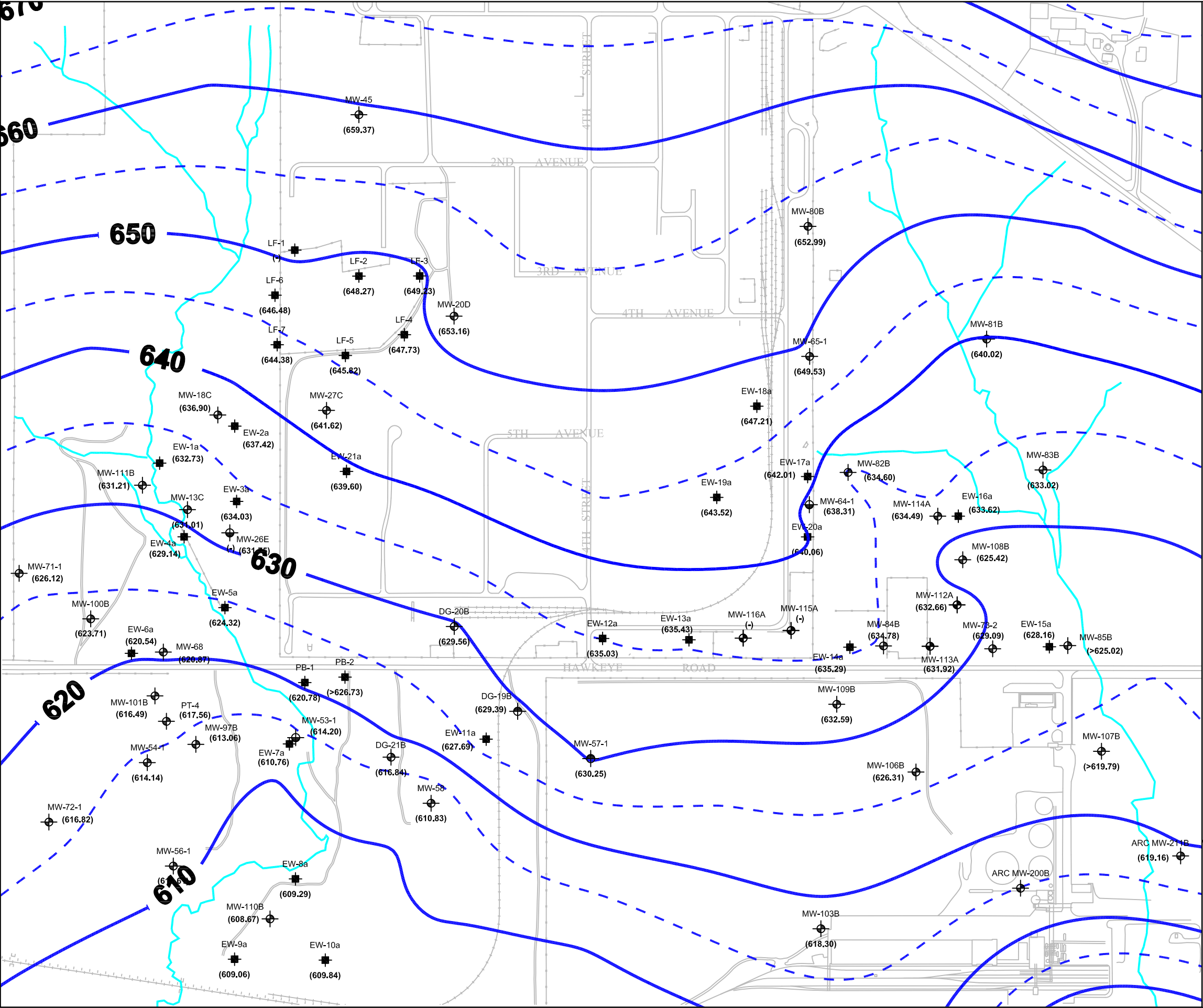
Some wells displayed are screened in underlying or overlying formations, as indicated by the well symbols.

Groundwater elevations marked with a greater-than sign (>) were artesian or flowing artesian on the date of measurement.

Erler & Kalinowski, Inc.

Upper Scotch Grove Formation
May 2010 Potentiometric Surface

Chemplex Site, First OU
Clinton, IA
November 2011
EKI 890052.67
Figure 3-5



N

0 500 1,000

(Approximate Scale in Feet)

★ Upper Scotch Grove Extraction Well

⊕ Lower Scotch Grove Monitoring Well

⊙ Picture Rock Monitoring Well

660 Groundwater Elevation Contour in Feet Above Mean Sea Level

(637.65) Groundwater Elevation in Feet Above Mean Sea Level, Measured in Wells on 10 May 2010

Notes:

All locations are approximate.

Contour Interval: 5 feet

On 29 September 2008, groundwater extraction in the Upper Scotch Grove Unit was discontinued.

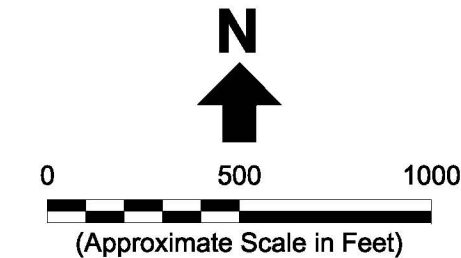
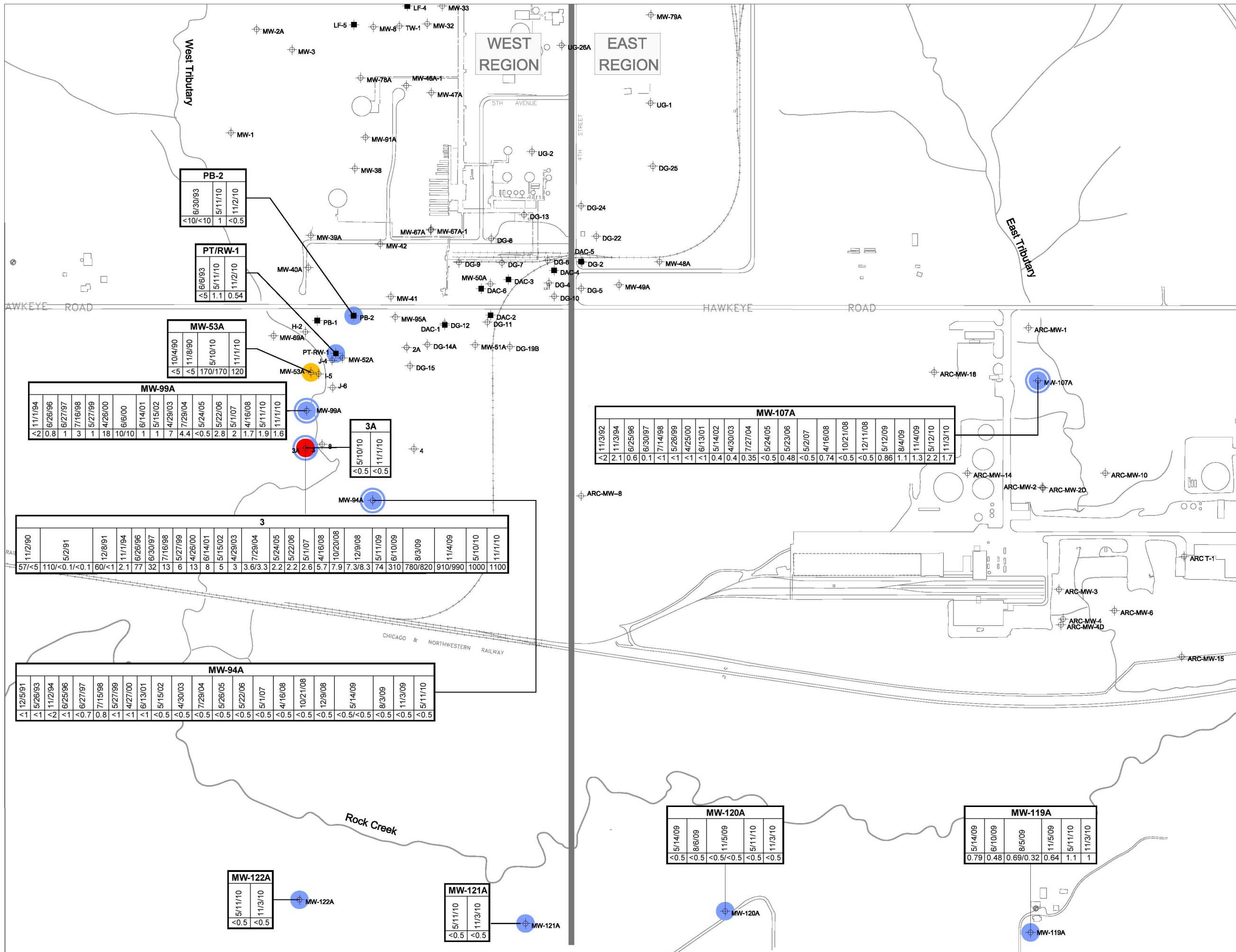
Some wells displayed are screened in underlying or overlying formations, as indicated by the well symbols.

Groundwater elevations marked with a greater-than sign (>) were artesian or flowing artesian on the date of measurement.

Erler & Kalinowski, Inc.

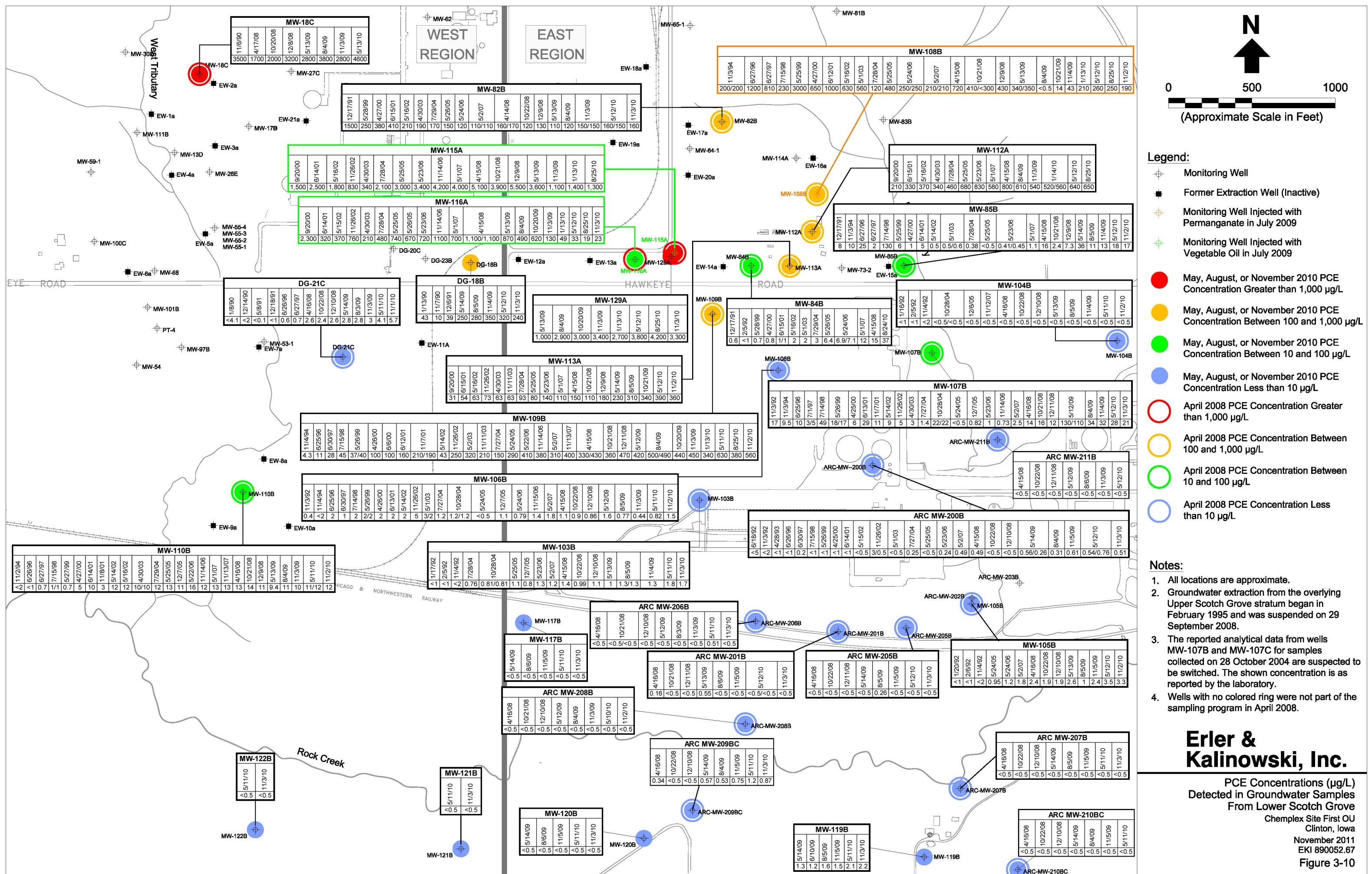
Lower Scotch Grove Formation
May 2010 Potentiometric Surface

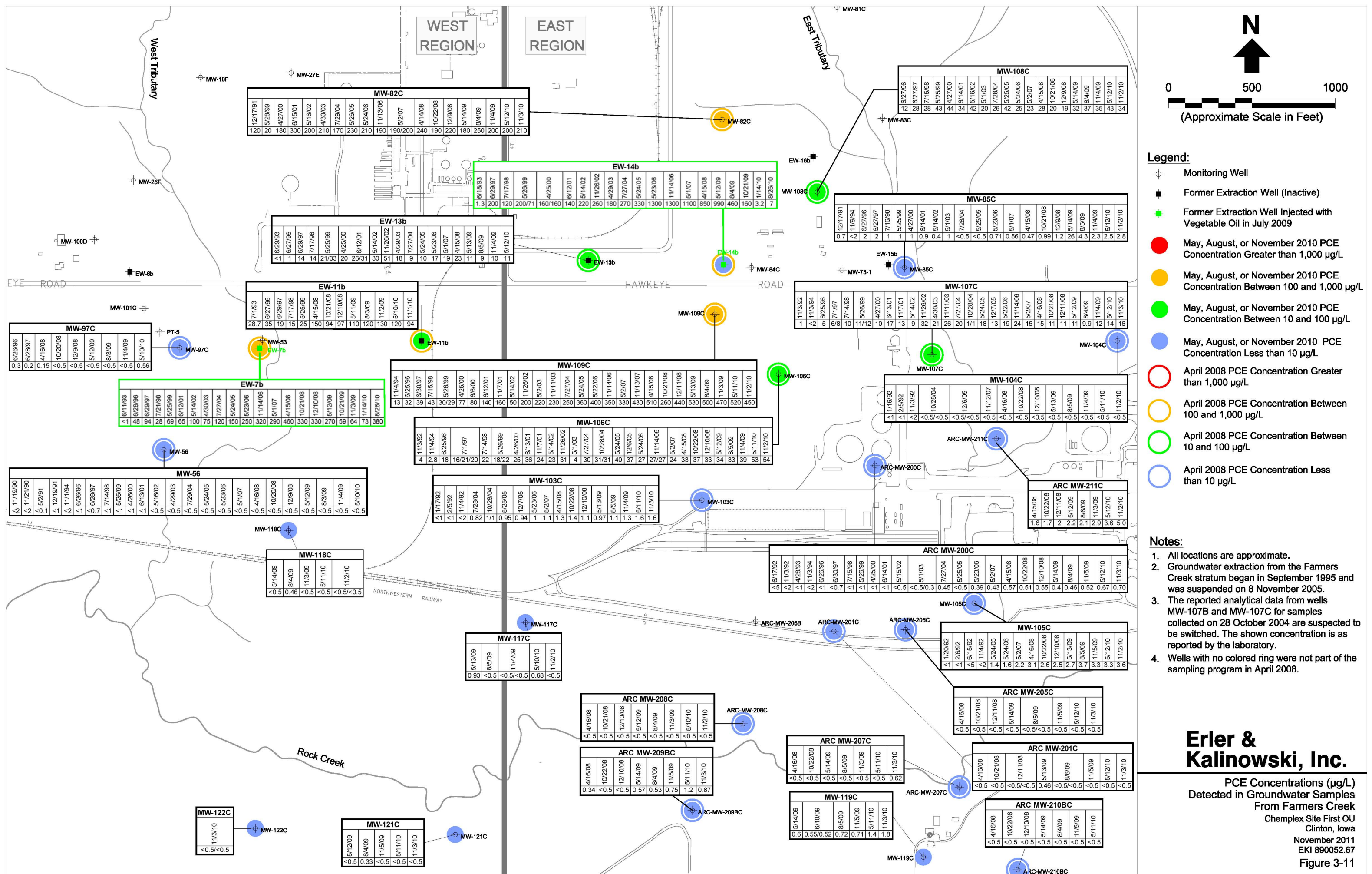
Chemplex Site, First OU
Clinton, IA
November 2011
EKI 890052.67
Figure 3-6

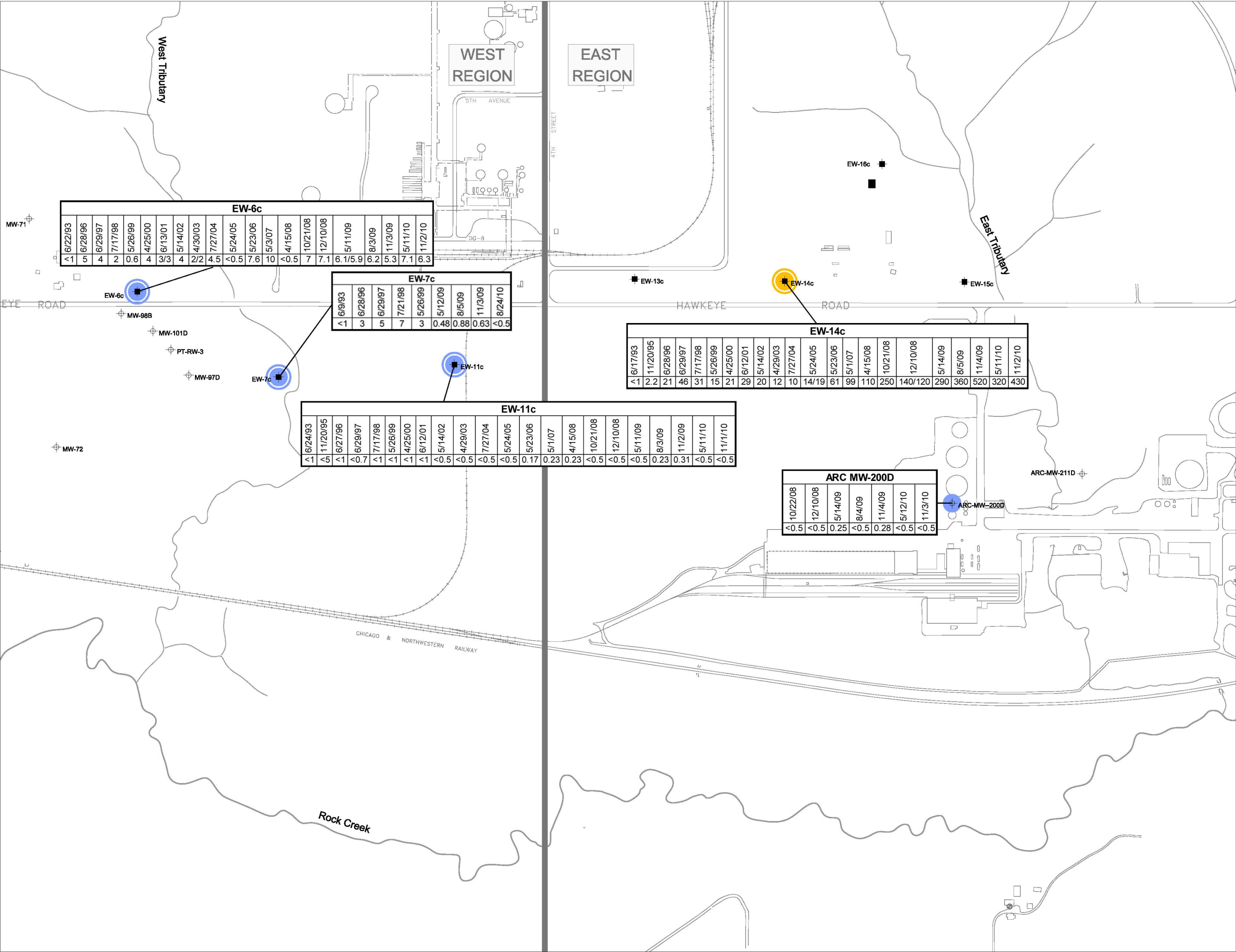


- Legend:**
- Monitoring Well
 - Former Extraction Well (Inactive)
 - May or November 2010 PCE Concentration Greater than 1,000 µg/L
 - May or November 2010 PCE Concentration Between 100 and 1,000 µg/L
 - May or November 2010 PCE Concentration Between 10 and 100 µg/L
 - May or November 2010 PCE Concentration Less than 10 µg/L
 - April 2008 PCE Concentration Greater than 1,000 µg/L
 - April 2008 PCE Concentration Between 100 and 1,000 µg/L
 - April 2008 PCE Concentration Between 10 and 100 µg/L
 - April 2008 PCE Concentration Less than 10 µg/L

- Notes:**
- All locations are approximate.
 - Groundwater extraction from this stratum began in December 1994 and was suspended on 29 September 2008.
 - Wells with no colored ring were not part of the sampling program in April 2008.







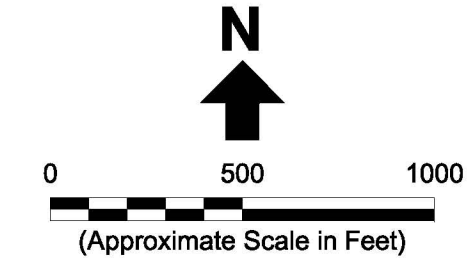
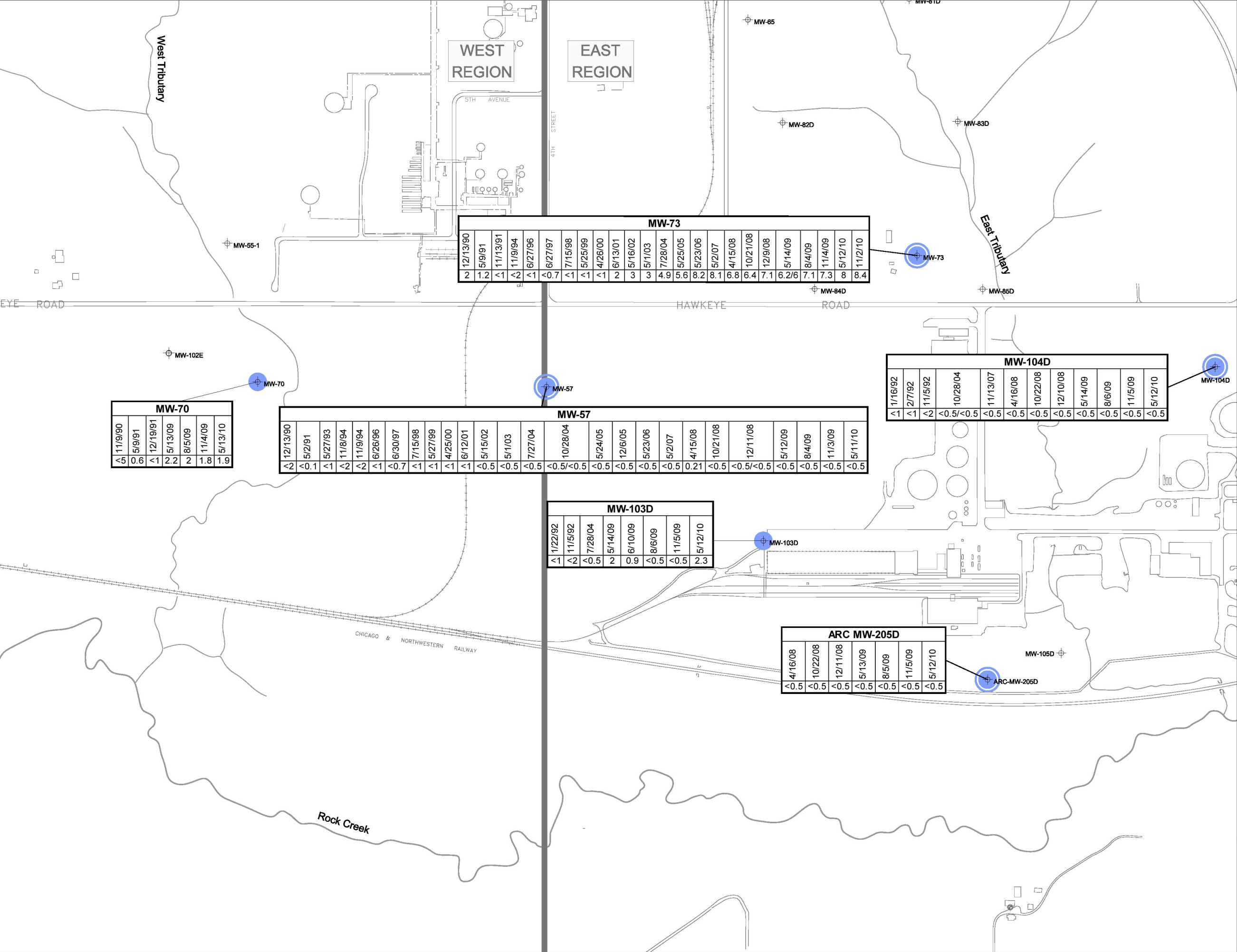
N

0 500 1000

(Approximate Scale in Feet)

Erler & Kalinowski, Inc.

PCE Concentrations (µg/L)
Detected in Groundwater Samples
From Lower Hopkinton
Chemplex Site First OU
Clinton, Iowa
November 2011
EKI 890052.67
Figure 3-12

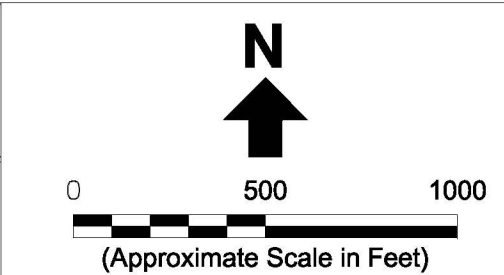
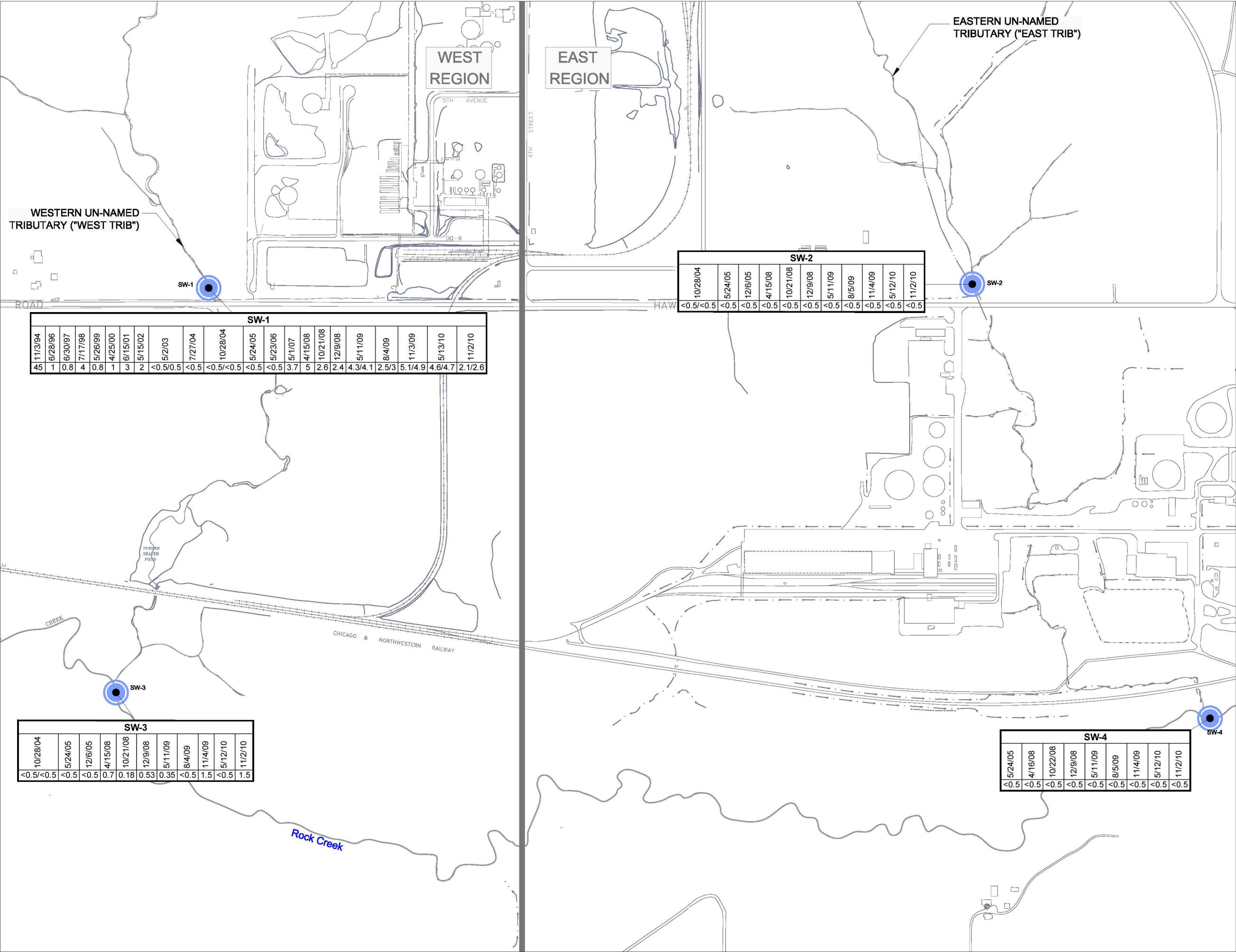


- Legend:**
- Monitoring Well
 - Former Extraction Well (Inactive)
 - May or November 2010 PCE Concentration Greater than 1,000 µg/L
 - May or November 2010 PCE Concentration Between 100 and 1,000 µg/L
 - May or November 2010 PCE Concentration Between 10 and 100 µg/L
 - May or November 2010 PCE Concentration Less than 10 µg/L
 - April 2008 PCE Concentration Greater than 1,000 µg/L
 - April 2008 PCE Concentration Between 100 and 1,000 µg/L
 - April 2008 PCE Concentration Between 10 and 100 µg/L
 - April 2008 PCE Concentration Less than 10 µg/L

- Notes:**
- All locations are approximate.
 - Groundwater extraction from the overlying Lower Hopkinton Stratum began on 18 November 1995 and was suspended on 17 March 1999.
 - Wells with no colored ring were not part of the sampling program in April 2008.

Erler & Kalinowski, Inc.

PCE Concentration (µg/L)
Detected in Groundwater Samples
From Blanding
Chemplex Site First OU
Clinton, Iowa
November 2011
EKI 890052.67
Figure 3-13



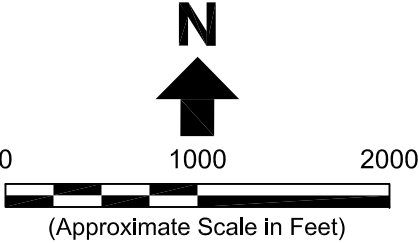
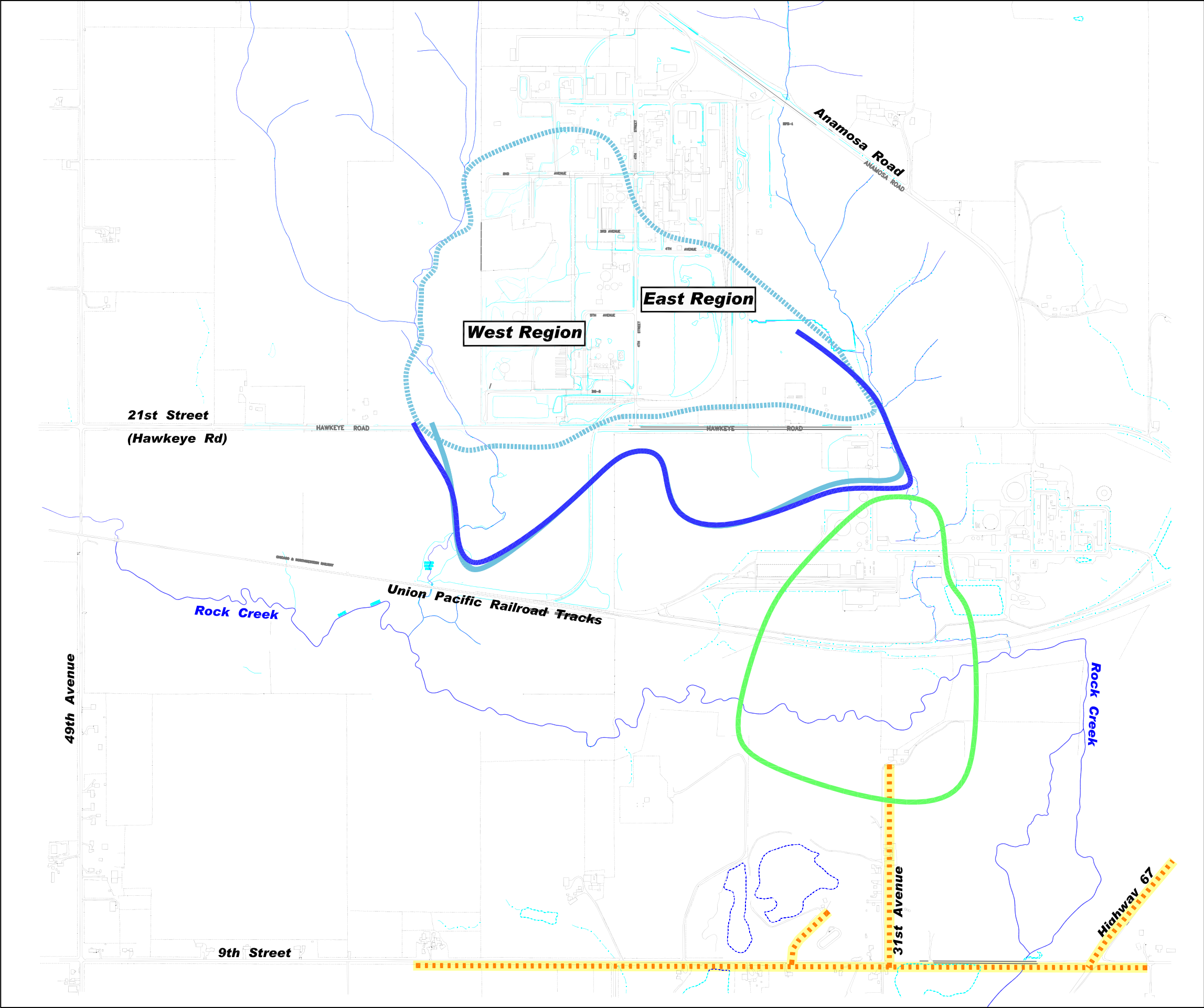
- Legend:**
- Surface Water Sample
 - November 2010 PCE Concentration Greater than 1,000 µg/L
 - November 2010 PCE Concentration Between 100 and 1,000 µg/L
 - November 2010 PCE Concentration Between 10 and 100 µg/L
 - November 2010 PCE Concentration Less than 10 µg/L
 - April 2008 PCE Concentration Greater than 1,000 µg/L
 - April 2008 PCE Concentration Between 100 and 1,000 µg/L
 - April 2008 PCE Concentration Between 10 and 100 µg/L
 - April 2008 PCE Concentration Less than 10 µg/L

- Notes:**
1. All locations are approximate.

Erler & Kalinowski, Inc.

PCE Concentrations (µg/L)
in Surface Water Samples

Chemplex Site First OU
Clinton, Iowa
November 2011
EKI 890052.67
Figure 3-14



Legend:

- 1992 PCE Groundwater Plume Contour (10 ug/L)
- 2008 PCE Groundwater Plume Contour (5 ug/L)
- 2011 PCE Groundwater Plume Contour (5 ug/L)
- 2008 Nitrate in Groundwater Plume Contour (10 mg/L)
- Municipal Water System Extension

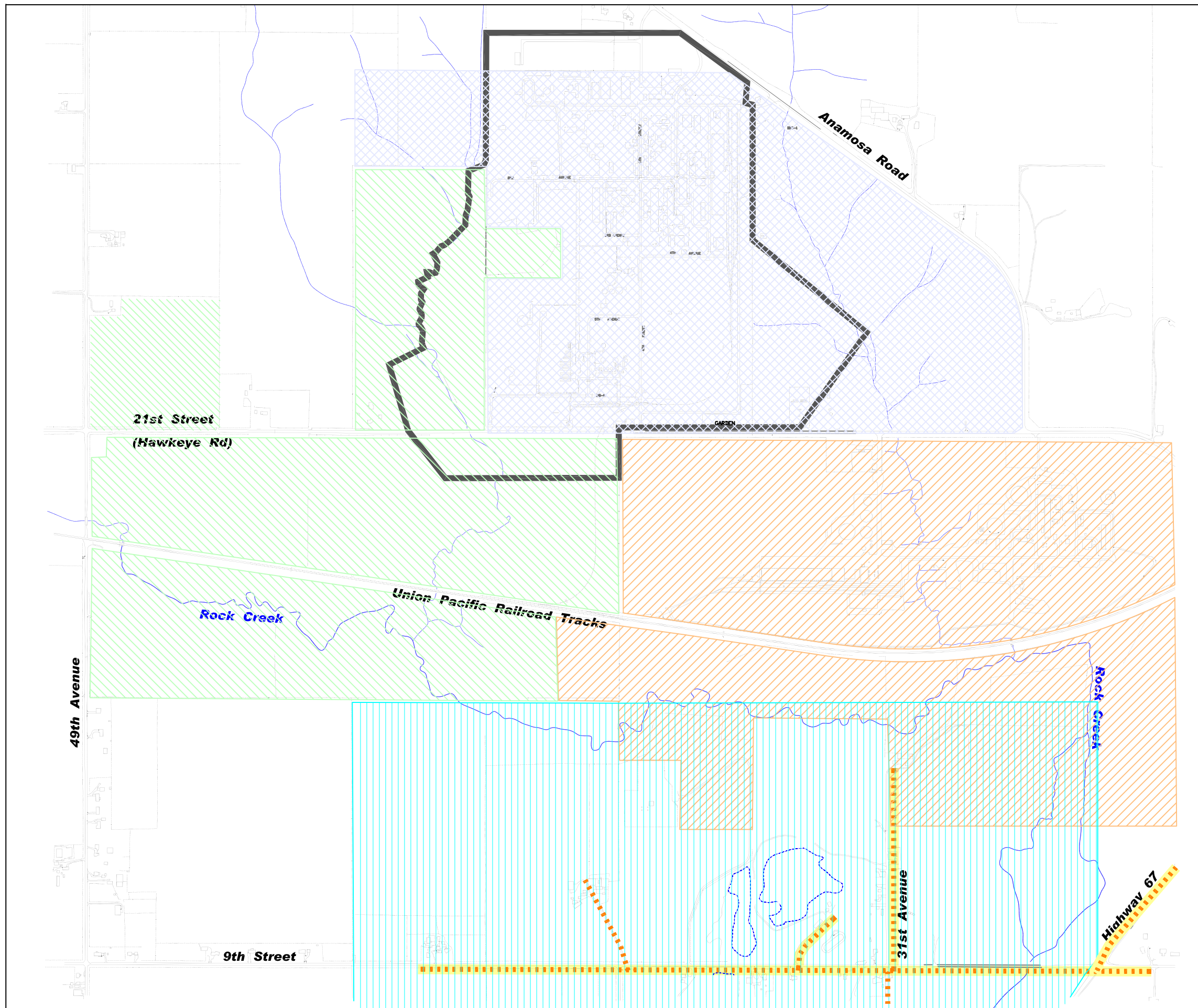
Notes:

1. The 2008 PCE concentration contour is based on data from April 2008, while the 2011 PCE concentration contour is based on data from November 2011.
2. The 1992 tetrachloroethene ("PCE") concentration contour was based on concentrations reported in Montgomery Watson's *First Operable Unit Remedial Investigation Report*, dated August 1992.
3. The 2008 nitrate concentration contour was as reported in MACTECs *Report of Annual Monitoring and Remediation for 2008, PCS Nitrogen, Clinton, Iowa*, dated 25 March 2009.







**Erler &
Kalinowski, Inc.**

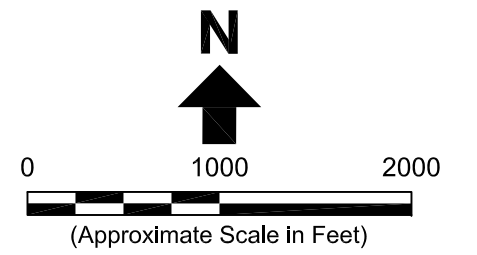
Summary of PCE Plume in Groundwater
Over Time

Chemplex Site, First OU
Clinton, Iowa
December 2011
EKI 890052.67
Figure 3-15



Legend:

-  Current Point of Compliance Boundary
-  Municipal Water System Extension
-  Area of ACC/GCC Environmental Covenant
-  Area of Equistar Environmental Covenant
-  Area of Crossroads Environmental Covenant
-  Area of Camanche Ordinance



**Erler &
Kalinowski, Inc.**

Environmental Covenants and
Ordinance Area Boundaries

Chemplex Site, First OU
Clinton, Iowa
November 2011
EKI 890052.67
Figure 4-1

APPENDIX A:

***Hot Spot Pilot Test Evaluation Report, prepared by MWH Americas, Inc.,
dated 21 December 2010***

HOT SPOT PILOT TEST EVALUATION REPORT

FOR

CHEMPLEX SITE IN CLINTON, IOWA

Prepared For

ACC/GCC

Project No. 1006907.0104

December 2010

Prepared by

MWH

**11153 Aurora Avenue
Des Moines, Iowa 50322
515-253-0830**

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SECTION 1.0 – INTRODUCTION

This Hot Spot Pilot Test Evaluation Report (Evaluation Report) documents the Hot Spot Pilot Study (pilot study) conducted at the Chemplex site in Clinton, Iowa as part of the implementation of the Hot Spot Pilot Test Work Plan (Work Plan) dated March 2009 (MWH, 2009a). The Work Plan was developed in response to Paragraph 5 of the “Chemplex Site Statement of Additional Work” set forth by the United States Environmental Protection Agency (EPA) in its letter dated April 9, 2008.

Solutions of vegetable oil or permanganate were injected in designated monitoring wells and former extraction wells in July 2009. This initial field work was documented in the Hot Spot Pilot Test Field Activities Summary, dated October 2009 (MWH 2009b) (Field Summary Report). This Evaluation Report presents analytical data collected since baseline sampling was completed in May 2009. An interim report, titled Hot Spot Pilot Study – 6-Month Progress Report, was issued in May 2010 (MWH, 2010).

This Evaluation Report describes the activities and analytical data at each injection and monitoring location associated with the Hot Spot Pilot Test. This Evaluation Report also draws conclusions and provides recommendations regarding potential future application of vegetable oil and permanganate to address hot spots of chlorinated ethenes in Chemplex Site groundwater. EPA comments on the 6-Month Progress Report are also addressed by this Evaluation Report.

1.1 PURPOSE

As described in the Work Plan, the hot spot pilot test assessed the viability of in-situ treatment to mitigate localized “hot spots” of perchloroethene (PCE) in Chemplex Site groundwater. Hot spot treatment is a component of the revised groundwater remedy identified as Alternative 3 – Exposure Control in the Final Focused Feasibility Study (Erler & Kalinowski, Inc. [EKI], 2007).

1.2 INJECTION SUMMARY

Vegetable oil was injected at five locations (monitoring wells MW-115A and MW-116A; and former groundwater extraction wells EW-3a, EW-7b, and EW-14b) to provide supplemental electron donor to promote growth of PCE-degrading microbes. Looking at progressively-deeper bedrock layers, former groundwater extraction well EW-3a is screened in the Upper Scotch Grove formation, monitoring wells MW-115A and MW-116A are screened in the Lower Scotch Grove formation, and former extraction wells EW-7b and EW-14b are screened in the Farmers Creek stratum of the Lower Hopkinton formation.

Permanganate, a strong oxidant, was injected at monitoring well MW-108B, screened in the Lower Scotch Grove formation, in an effort to oxidize PCE and other chlorinated ethene volatile organic compounds (VOCs). Figure 1 shows the pilot study injection and monitoring locations. The Field Summary Report, which details injection procedures and quantities, is provided in Appendix A for reference.

1.3 GROUNDWATER SAMPLING SUMMARY

The hot spot pilot test monitoring program included baseline sampling and post-injection sampling at approximately 1, 3, 6, and 12 months after injection. Monitoring included sampling for VOCs and other analytes traditionally used to assess natural attenuation processes. Monitoring for pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) was typically conducted during each sampling event. Compound-specific isotope analysis (CSIA) was also performed at most monitoring locations to examine changes in isotopic ratios of carbon in PCE and its daughter products in an effort to discern between abiotic and biological depletion mechanisms. Conditions at individual wells, as noted in subsequent sections, led to modification of the sampling frequency and program at some locations.

Analytical data collected through the 12-month stage of the Hot Spot Pilot Test, including baseline sampling, were organized by monitoring location as presented in Tables 1 through 9. These tables also include other groundwater sampling results collected during the site-wide Performance Monitoring Evaluation (PME) monitoring events that were conducted between pilot study baseline sampling in May 2009 and the 12-month sampling event in August 2010.

1.4 COMPOUND-SPECIFIC ISOTOPE ANALYSIS

CSIA was performed for the baseline, 3-month, and 12-month post-injection sampling events at selected wells. The analyses were performed by Microseeps, Inc. of Pittsburgh, Pennsylvania (Microseeps), a laboratory specializing in CSIA. CSIA can be useful for differentiating biological degradation, which changes isotope ratios, from abiotic mechanisms such as dilution or sorption, which do not change the isotope ratio. CSIA principles and applications can be found in EPA's *A Guide for Assessing Biodegradation and Source Identification of Organic Ground Water Contaminants Using Compound Specific Isotope Analysis*, December 2008 (EPA, 2008). Laboratory reports from Microseeps are provided in Appendix B.

For the Chemplex site, CSIA was applied to the carbon atoms in PCE, trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride. The carbon isotopes of interest are carbon-12 (^{12}C) and the heavier carbon-13 (^{13}C). The CSIA results are presented as a relative abundance ratio of ^{13}C to ^{12}C , as referenced to an isotope standard, expressed as delta ^{13}C ($\delta^{13}\text{C}$).

As the relative abundance of ^{13}C to ^{12}C increases (and $\delta^{13}\text{C}$ becomes a more positive value), this indicates the lighter carbon isotope (^{12}C) is being depleted at a faster rate than the heavier carbon isotope (^{13}C). Preferential degradation occurs because molecules with the lighter carbon isotopes have slightly weaker covalent bonds that are slightly easier for microbial enzymes to break. This progressive depletion of the lighter carbon isotope is indicative of biological degradation.

These ratios must also be interpreted to reflect progressive changes in the isotope ratio of the parent compound. For example, biological degradation of parent compound PCE should result in enrichment of ^{13}C in the remaining PCE, as the lighter fraction is preferentially transformed to the initial daughter compound TCE, and the lighter ^{12}C fraction in the TCE should thus increase.

TCE at the same time acts as a parent compound that can be degraded biologically, concentrating ^{13}C over time in the remaining TCE, as the lighter ^{12}C -containing TCE molecules are preferentially degraded to cis-1,2-DCE. Changes in $\delta^{13}\text{C}$ of at least 2‰ (two parts per thousand) are considered significant (EPA, 2008).

For several samples there was a significant difference in concentrations reported by Microseeps and the routine Chemplex analytical laboratory, ALS Laboratory Group of Salt Lake City, Utah (ALS). When reporting $\delta^{13}\text{C}$, this Evaluation Report uses the Microseeps data. As $\delta^{13}\text{C}$ is a ratio, the analyte concentrations reported by Microseeps were assumed to not significantly affect the isotope ratio. All absolute concentrations presented in this Evaluation Report are as reported by ALS, which has a long history of VOC reporting and data validation for the Chemplex site.

SECTION 2.0 – VEGETABLE OIL INJECTION LOCATIONS

2.1 INJECTION POINT MW-115A

2.1.1 Injection Summary

Monitoring well MW-115A is a 2-inch diameter well, with a total depth of 120 feet screened in the Lower Scotch Grove formation. Approximately 287 gallons of concentrated (60 percent) vegetable oil and 53 gallons of chase water were injected into MW-115A. Although a total of 450 gallons of concentrated vegetable oil was targeted for injection based on the evaluation described in the Work Plan, this well was unable to accept the total planned vegetable oil and chase water injection volumes. Despite extended efforts, injection flow rates slowed to less than 0.25 gallon per minute (gpm) prior to cessation of injection activities.

2.1.2 Current Physical Condition

Due to MW-115A not being able to accept the full planned volume of chase water during the injection phase, the water column in MW-115A still contained vegetable oil as of August 2010. Purge water collected prior to sampling of MW-115A in August 2010 was milky white, foamy, and had a faint sour odor, indicating the continued presence of emulsified oil. The presence of residual oil precluded sampling during the 1- and 3-month post-injection monitoring events.

When sampling MW-115A, a small-volume purge was completed to minimize the amount of vegetable oil-laden water handled above grade. Samples were then collected for analyses of VOCs and natural attenuation analytes. Field parameters such as pH, ORP, DO, and temperature were not measured due to the presence of vegetable oil that would damage the membranes on the monitoring equipment. While purge water can sometimes be filtered to remove residual vegetable oil, the amount of residual vegetable oil in solution led to clogged filters before the volume required for monitoring could be collected. The residual oil at MW-115A has limited the monitoring data available for evaluation.

2.1.3 Analytical Data

Groundwater monitoring data collected since the May 2009 hot spot baseline sampling for MW-115A are presented in Table 1 and Figure 2. Concentrations of PCE, TCE, and cis-1,2-DCE have all decreased at MW-115A following the vegetable oil injection event. The well was sampled in November 2009 during the PME site-wide sampling event (approximately 4 months post-injection), during the January 2010 6-month post-injection sampling event, and during the August 2010 12-month post-injection sampling event. MW-115A was not sampled during the 1- and 3-month post-injection events, due to a high concentration of residual vegetable oil in the water column.

The elevated total organic carbon (TOC) concentrations (24,000,000 micrograms per liter [$\mu\text{g/L}$] in August 2010), compared to the baseline conditions (6,100 $\mu\text{g/L}$), indicate significant vegetable oil remains in or around MW-115A.

Ammonia concentrations (30,000 to 38,000 µg/L as nitrogen [N]) increased significantly post-injection compared to the baseline concentrations (<50 µg/L); probably due to the breakdown of proteins and amino acids contained in the vegetable-based oil. Between January 2010 and August 2010, the reported ammonia concentration decreased from 38,000 µg/L to 30,000 µg/L as N. Coupled with the decreasing concentrations of TOC (from 35,000,000 µg/L to 24,000,000 µg/L between November 2009 and August 2010), this indicates a breakdown of the vegetable oil product is actively occurring.

Concentrations of competing electron acceptors nitrate and sulfate have decreased since the vegetable oil injection, presumably because the vegetable oil furnishes ample electron donor for anaerobic bacteria using nitrate or sulfate as electron acceptors. Carbonate alkalinity has increased from 280 to 2,300 milligrams per liter (mg/L), potentially the result of dissolution of the carbonate-containing dolomite matrix caused by production of fatty acid products during vegetable oil breakdown. It is likely the well and its immediately surrounding area are now under reducing conditions as evidenced by the increase in dissolved methane, iron, and manganese concentrations.

Post-injection concentrations of ethane and ethene have decreased from the baseline concentrations of 52 µg/L and 23 µg/L to less than 5 µg/L and 8 µg/L, respectively in August 2010. As shown in Table 2, concentrations of chlorinated ethenes have been similar over the last three sampling events, at levels lower than the baseline concentrations. The consistent, but lower concentrations of ethane and ethene may be related to smaller mass of parent vinyl chloride available after the vegetable oil injection.

Samples were collected for CSIA during the baseline and 12-month sampling events. The results, shown in Tables 1 and 10, indicated no significant change in the isotope fractionation of PCE; however, the remaining TCE and cis-1,2-DCE showed enrichment of ¹²C. This indicates the lighter ¹²C fraction is being preferentially degraded from the parent compounds. Vinyl chloride, however, showed an enrichment of ¹³C. This is likely because the conversion of cis-1,2-DCE to vinyl chloride is the rate-limiting step in the PCE microbial degradation pathway. As the biological activity is increased and more vinyl chloride is degraded, the relative abundance of ¹²C-containing vinyl chloride is not significantly enhanced relative to the rate of vinyl chloride degradation. The CSIA data indicate there is an increase in biological degradation activities at MW-115A following vegetable oil injection.

2.2 INJECTION POINT MW-116A

2.2.1 Injection Summary

Monitoring well MW-116A is a 2-inch diameter well, with a total depth of 118 feet screened in the Lower Scotch Grove formation. In total, approximately 8 gallons of concentrated (60 percent) vegetable oil and 28 gallons of chase water were injected into MW-116A. This was less than the planned injection of 400 gallons of concentrated vegetable oil. Shortly after injection at MW-116A started, a rapidly decreasing flow rate similar to the pattern observed at

MW-115A occurred. The injection at MW-116A was halted to prevent the vegetable oil accumulation that occurred at MW-115A.

2.2.2 Current Physical Condition

As of August 2010, the water column at MW-116A was cloudy from residual vegetable oil and contained grey granules that appear to be a vegetable oil breakdown product. The residual vegetable oil has not precluded sampling of the well, but a small-volume purge is typically completed, with the purge water filtered prior to field monitoring rather than monitored directly in a flow-through cell. As a result of this filtering process, the recorded DO readings were likely biased high due to mixing with atmospheric air.

2.2.3 Analytical Data

MW-116A has been sampled during the 1-, 3-, 6-, and 12-month post-injection events, and PME sampling events in November 2009 and May 2010. Analytical results for MW-116A are presented in Table 2 and Figure 3. The PCE concentration results show an overall declining trend from 870 µg/L in the pre-injection sampling to 19 µg/L for the 12-month post-injection sampling event. Overall decreases in the concentrations of PCE daughter products (TCE and vinyl chloride) were observed; the concentration of cis-1,2-DCE decreased initially but has rebounded to near pre-injection levels. Cis-1,2-DCE commonly accumulates during reductive dechlorination and the concentration pattern is typical of biological degradation.

The CSIA analysis (Tables 2 and 10) for TCE collected during the 3-month post-injection event displayed a much more negative $\delta^{13}\text{C}$ isotopic ratio, indicative of biological degradation of PCE leading to enrichment of ^{12}C in the TCE daughter product. For the August 2010 (12-month) sampling data, however, the $\delta^{13}\text{C}$ had returned to pre-injection levels. The ^{12}C fraction of cis-1,2-DCE increased slightly over the course of the pilot study. The combination of CSIA data and sustained cis-1,2-DCE concentration, while PCE concentration remains low, indicates biological degradation of chlorinated ethenes is occurring at MW-116A rather than dilution.

The TOC measured at MW-116A has been lower than at other vegetable oil injection points. This is likely caused by the smaller amount of total vegetable oil mass injected compared to the other wells. Despite the low oil injection mass, there has been a significant decrease in concentration of VOCs.

The groundwater pH decreased a full unit between the November 2009 PME monitoring event (6.75 units) and the January 2010 6-month post-injection sampling event (5.65 units). The pH value of 5.65 is outside the ideal range for dechlorinating bacteria of approximately pH 6 to 8 (Air Force Center for Engineering and the Environment [AFCEE], 2007). The pH decrease could have resulted from the formation of fatty acids or other organic acids from the fermentation of vegetable oil. For the August 2010 sampling event, the measured pH value was 6.02. The ORP at MW-116A was consistently between -80 and -100 millivolts (mV) since the vegetable oil injection, compared to the baseline value of -4 mV, indicating a reducing environment.

There was a significant increase in methane concentration noted for the 6-month and 12-month post-injection sampling events, suggesting oil biodegradation under anoxic conditions. The concentration of dissolved and total iron has increased following the vegetable oil injection. These observations are consistent with the decreasing ORP values and decreasing nitrate and sulfate concentrations. These preliminary indicators suggest the environment near MW-116A is becoming more conducive to reductive dechlorination.

Ethane and ethene concentrations spiked slightly immediately following the injection. Thereafter, the concentrations have generally declined and no ethane or ethene was reported in the sample collected August 2010. This pattern reflects the concentration trend observed for vinyl chloride which would serve as the parent compound to ethene.

After one year of groundwater monitoring, the results show that the vegetable oil injection is having a sustained effect of reducing VOC concentrations at MW-116A and creating conditions (low sulfate and nitrate concentrations, reducing environment) conducive to reductive dechlorination.

2.3 INJECTION POINT EW-7b

2.3.1 Injection Summary

Former extraction well EW-7b is an 8-inch diameter well with a total depth of 163 feet screened in the Farmers Creek stratum. 217 gallons of concentrated (60 percent) vegetable oil and 24 gallons of chase water were injected into well EW-7b, close to the targeted injection volume of 250 gallons of concentrated vegetable oil. The injection and chase water volumes were somewhat less than planned because the well stopped accepting vegetable oil and chase water.

2.3.2 Current Physical Condition

As of August 2010, there is significant vegetable oil remaining in the EW-7b water column that has precluded field monitoring for pH, ORP, and DO. A pneumatic bladder pump remains in the well and is used for purging and sample collection. The purge water in January 2010 was whitish in color and was too thick with vegetable oil to be filtered for field monitoring. Residual vegetable oil observed in EW-7b visually appears less degraded than the residual vegetable oil at MW-115A. A small purge was completed prior to collecting analytical samples.

2.3.3 Analytical Data

Table 3 and Figure 4 present the analytical data for EW-7b for the baseline, 3-month, 6-month, and 12-month post-injection monitoring events; the November 2009 PME sampling event results are also included. EW-7b was not sampled during the 1-month post-injection event due to a high concentration of residual vegetable oil in the water column. There was a decrease in reported PCE concentrations between the baseline and subsequent sampling events through the 6-month post injection event, from 270 µg/L to about 60 µg/L to 70 µg/L. For the 12-month post-injection sampling event, the reported PCE concentration was 380 µg/L, somewhat higher

than the baseline result. Ethane and ethene concentrations have decreased following the vegetable oil injection.

There were some significant changes between the 6-month and 12-month post injection event sample results at EW-7b. The concentration of PCE rose from 73 µg/L to 380 µg/L. Methane concentration increased from 2,400 µg/L to 16,000 µg/L, and total iron increased from 97,000 µg/L to 230,000 µg/L, which is indicative of strongly reducing conditions. The TOC content and ammonia concentration remained elevated.

Much of the information collected from EW-7b, like data from MW-115A, must be considered in light of the difficulties encountered during the injection phase. Due to the well not accepting flush water, vegetable oil was not pushed into the formation and the well, filter pack, and surrounding area likely contain a high concentration of vegetable oil that is breaking down in place and is only slowly being removed by advective flux or diffusion. The accumulated vegetable oil and breakdown products are likely leading to elevated pH conditions and the observed high ammonia concentrations.

Due to the low concentrations of chlorinated ethenes in EW-7b following the vegetable oil injection, CSIA results (presented in Table 3 and 10) show little conclusive data. There is no fractionation of PCE noted and the apparent enrichment of ¹²C in TCE is inconclusive, as ALS reported no detection of TCE (Table 3).

2.4 INJECTION POINT EW-14b

2.4.1 Injection Summary

Former extraction well EW-14b is an 8-inch diameter well with a total depth of 173 feet screened in the Farmers Creek stratum. Approximately 273 gallons of concentrated (60 percent) vegetable oil and 400 gallons of chase water were injected into well EW-14b. This injected vegetable oil volume matched the planned injection volume and the well readily accepted the injection solutions.

2.4.2 Current Physical Condition

The water column in former extraction well EW-14b displayed a faint white color and a slight film was noted on purge water. During the 12-month sampling event the pneumatic bladder pump was not functioning properly and was removed after on-site cleaning with hot water did not restore function. The 12-month sample was collected using Waterra tubing.

2.4.3 Analytical Data

The analytical data from EW-14b exhibit decreasing concentrations of PCE, TCE, and vinyl chloride, as shown in Table 4 and Figure 5. The concentration of cis-1,2-DCE increased between the baseline and 6-month sampling events. The biological conversion of cis-1,2-DCE to vinyl chloride is typically the rate-limiting step in the degradation of PCE to ethene and ethane; therefore, an accumulation of cis-1,2-DCE suggests biological degradation is occurring.

Ethane and ethene concentrations spiked slightly immediately following the injection. Thereafter, the concentrations have generally declined and no ethane or ethene was reported in the sample collected during August 2010. This pattern reflects the concentration trend observed for vinyl chloride which would serve as the parent compound to ethene.

CSIA results for PCE in well EW-14b show an increase in ^{13}C fraction between the baseline and 3-month sampling events, which was not observed at other locations. It is believed that as the PCE was degraded and additional PCE source material was not available for biological reduction, the ^{13}C fraction was increased, as expected. The CSIA analysis for cis-1,2-DCE collected during the 3-month post-injection event showed a $\delta^{13}\text{C}$ value that was significantly more negative relative to the baseline, indicative of a significant biological component to the degradation of PCE and TCE leading to an increased abundance of ^{12}C in cis-1,2-DCE. The extent of fractionation was less during the 12-month sampling event, perhaps because nearly all of the parent TCE compound had been degraded. There was not sufficient mass of PCE or TCE remaining at the 12-month event to perform CSIA analysis.

Concentrations of all chlorinated ethenes except cis-1,2-DCE have seen a significant decrease between baseline sampling and the August 2010 sampling event (PCE 99 percent reduced, TCE 100 percent reduced, cis-1,2-DCE essentially unchanged, and vinyl chloride 44 percent reduced). The apparent accumulation of cis-1,2-DCE and concentration of the lighter ^{12}C fraction in the cis-1,2-DCE indicate the chlorinated ethenes are being reduced through a biological degradation process rather than dilution or sorption.

Elevated concentrations of TOC indicate significant amounts of residual vegetable oil remain in the formation. The reported TOC concentration decreased from 1,300,000 $\mu\text{g/L}$ during the 6-month post-injection sampling event to 320,000 $\mu\text{g/L}$ during the 12-month event. This indicates the remaining vegetable oil at EW-14b is breaking down or being distributed in the formation. The pH has decreased and the methane and dissolved iron concentrations have increased which is indicative of strongly reducing conditions. The measured pH for the 6-month post-injection sampling event of 5.64 is outside the ideal pH range of 6 to 8 for biological degradation of PCE (AFCEE, 2007).

2.5 INJECTION POINT EW-3a

2.5.1 Injection Summary

Well EW-3a is an 8-inch diameter former extraction well with a total depth of 98 feet screened in the highly-weathered Upper Scotch Grove formation and the soil overburden. The well was not originally planned to be an injection point, but was identified as a suitable location for injecting remaining oil solutions while targeting a Chemplex site area with historically elevated PCE concentrations. Approximately 585 gallons of concentrated (60 percent) vegetable oil and 400 gallons of chase water were injected into well EW-3a.

2.5.2 Current Physical Condition

As shown in Table 5 and Figure 6, well EW-3a was first sampled for the hot spot analyte list during the 6-month sampling event. As of January 2010, the water column contained nearly 3 feet of vegetable oil solution in a separate phase above the water elevation. The vegetable oil emitted a pungent odor, even during the cold conditions in January 2010, suggesting anaerobic degradation in the water column. Significant vegetable oil remained in the water column when EW-3a was sampled in August 2010.

A direct current (DC) pump was installed with an intake in the screened portion of EW-3a prior to the January 2010 sampling event. A small volume of liquid was purged from the well before collecting the sample. No field monitoring was completed due to the high concentration of vegetable oil in the purge water.

2.5.3 Analytical Data

There was no baseline sampling of EW-3a conducted in 2009. The most recent pre-injection sample for EW-3a was collected in May 1999; the results are included in Table 5 and Figure 6. The well was added to the Hot Spot Pilot Test sampling program at the request of EPA, following review of the Field Summary Report; therefore, it was not included in the 1- or 3-month post-injection sampling events. The chlorinated ethenes concentrations reported in January 2010 were lower than reported in May 1999, although this decrease could have resulted from long-term concentration changes over time, dilution, post-injection biodegradation of products, or a combination of all three factors.

Between the 6-month and 12-month sampling events, the PCE concentration decreased from 200 µg/L to 40 µg/L in EW-3a. Decreases in reported concentrations of iron, manganese, and total organic carbon were also observed. The reported methane concentration increased from 330 µg/L in January 2010 to 19,000 µg/L during the 12-month sample event. This is the highest reported methane concentration in any of the injection wells. The methane result is indicative of a reducing environment and the remaining high concentrations of dissolved iron and manganese (38,000 µg/L and 1,300 µg/L, respectively) also indicate the establishment of a reducing environment.

SECTION 3.0 – PERMANGANATE INJECTION LOCATION

3.1 INJECTION SUMMARY

Monitoring well MW-108B, located on Equistar property east of the main fenced portion of the facility, was the single permanganate injection point. The 2-inch diameter well is approximately 104 feet deep and is screened in the Lower Scotch Grove formation. A total of 89 gallons of 40 percent permanganate solution were injected into MW-108B, followed by 150 gallons of chase water. The amount constituted the entire planned injection volume.

3.2 CURRENT PHYSICAL CONDITION

The injected sodium permanganate was a low viscosity liquid, and was easily injected in the formation and followed by chase water. Permanganate tints water purple and concentrated solutions can look black. The color of purge water from MW-108B was deep purple during the 1-month post-injection sampling and has continued to decrease in hue to a faint, light purple; and was effectively colorless during the August 2010 sampling event.

3.3 ANALYTICAL DATA

The analytical data for MW-108B (Table 6 and Figure 7) show a decrease in concentration of chlorinated ethenes at one month following the permanganate injection. The PCE concentration rebounded following the August 2009 1-month sampling event. For the 12-month (August 2010) sampling event, the PCE concentration (250 µg/L) was essentially unchanged from the May 2010 event (260 µg/L), but was less than the baseline event (350 µg/L). These results, showing a rapid decrease and subsequent rebound of PCE concentrations, are as expected. The manganese concentration has declined since the 1-month post injection sampling event, indicating the treated water is migrating, and/or manganese is precipitating from solution.

An increase of TOC to 71,000 µg/L, as compared to the baseline concentration of 740 µg/L, was reported during the 1-month post-injection sampling event. This increase was unanticipated because permanganate oxidizes organic matter and no organic matter was injected. The TOC concentration has since returned to pre-injection levels.

Field parameters, including ORP and DO, exhibited significant variability following the injection event without an evident trend. ORP has ranged from +52.6 mV to +456 mV following permanganate injection; the baseline value was -1 mV. Following the injection, DO values have ranged from a low of 2.66 mg/L in November 1999 to a high of 11.09 mg/L in January 2010. Following the permanganate injection, the groundwater environment was more oxidizing.

CSIA data (Tables 6 and 10) show a small change in carbon fractionation, although not at a significant level. This is as expected since permanganate oxidation is not biologically mediated.

SECTION 4.0 – MONITORING LOCATIONS

In addition to sampling conducted at the injection locations, there are three monitoring locations that are part of the pilot study. Monitoring wells MW-109B and MW-129A are downgradient of vegetable oil injection point MW-115A, and MW-112A is downgradient of permanganate injection point MW-108B.

4.1 DOWNGRAIENT OF MW-115A

Monitoring well MW-129A is approximately 33 feet downgradient (south) of vegetable oil injection point MW-115A, and monitoring well MW-109B is approximately 530 feet downgradient (southeast) of MW-115A. All three of these wells are screened in the Lower Scotch Grove formation; however, due to the fractured bedrock nature of the Chemplex site, there is no surety that the three wells are directly interconnected. MW-129A was installed to support the pilot study.

4.1.1 MW-109B

The analytical data at MW-109B (Table 7 and Figure 8), located downgradient of MW-115A, indicate no significant trends in groundwater conditions during the pilot study. The PCE concentration, as reported for the May 2009 pre-injection event, was 420 µg/L. In six subsequent sampling events the PCE concentration ranged between 340 µg/L and 630 µg/L, not much different from the initial value. Concentrations of PCE daughter products, TCE, and cis-1,2-DCE have fluctuated slightly. An increase to 1,300 mg/L TOC was reported in August 2009 but TOC concentrations were typically below the laboratory reporting limit for subsequent sampling points.

In the first post-injection event (August 2009), methane, ethane, and ethene were measured at approximately three times the levels recorded for the pre-injection (May 2009) sampling event. Ethane, ethene, and perhaps methane can form as daughter products of PCE biodegradation, and methane indicates the presence of reducing conditions. In subsequent sampling events, methane, ethane, and ethene have not been detected at MW-109B. CSIA data (Tables 7 and 10) show no significant isotope fractionation of chlorinated ethenes at MW-109B.

4.1.2 MW-129A

The analytical data (Table 8 and Figure 9) for monitoring point MW-129A indicate overall conditions in the vicinity of the well have changed since the July 2009 vegetable oil injection in MW-115A. PCE concentration increased from 1,000 µg/L in May 2009 to 4,200 µg/L during the August 2010 sampling event. Concentrations of PCE daughter products, including both chlorinated compounds (TCE, cis-1,2-DCE, and vinyl chloride) and nonchlorinated compounds (ethane, ethene, and methane), also increased during this timeframe. The increase in TOC concentration is small and indicates that injected vegetable oil has not reached MW-129A.

The reason for the increase in PCE and other chlorinated ethene concentrations is not known. The addition of vegetable oil could have promoted the back-diffusion of PCE and other chlorinated ethenes from nearby rock pores, as PCE would preferentially partition from the aqueous phase into the more hydrophobic oil. Another possibility is that the vegetable oil injection at MW-115A reduced groundwater flow through fractures that contained a lower concentration of PCE, resulting in higher concentrations moving toward MW-129A.

The CSIA data (Tables 8 and 10) do not indicate that the PCE, TCE, or cis-1,2-DCE concentrations have been biologically influenced since the beginning of the pilot study. The decrease in ORP suggests that the vegetable oil is having the desired effect of producing more reducing conditions conducive to reductive dechlorination. The injection at MW-115A has had an effect on conditions at MW-129A.

4.2 DOWNGRAIENT OF MW-108B

Monitoring well MW-112A is approximately 225 feet south of MW-108B, the permanganate injection point. Both monitoring wells are screened in the Lower Scotch Grove formation. MW-112A was added to the sampling list at the request of on-site EPA personnel during the permanganate injection. The MW-112A baseline data reported in Table 9 and Figure 10 are from April 2008. Sample results following the injection show little change. An increase in total manganese (from below the reporting limit to 38 µg/L) was noted during the August 2010 sampling event, suggesting that local groundwater was affected by the permanganate injection. It is unlikely that active oxidation by permanganate is still occurring one year after the injection, but rather a portion of the now reduced permanganate has reached MW-112A by groundwater advection. CSIA data (Tables 9 and 10) show no fractionation of chlorinated ethenes over the pilot study, as expected.

SECTION 5.0 – SUMMARY

5.1 VEGETABLE OIL INJECTION

The monitoring data indicate that the vegetable oil injection has promoted establishment of reducing conditions conducive to biologically mediated reductive dechlorination, as well as providing supplemental electron donor. Of the five oil injection wells, MW-115A, MW-116A, EW-3a, and EW-14b all showed declining concentrations of dissolved PCE, apparently in response to vegetable oil injection. Injection well EW-7b exhibited an initial PCE concentration decline, but by the 12-month sampling event the PCE had rebounded to levels exceeding baseline concentrations. At those injection points where the water column was not cleared of vegetable oil with chase water, particularly MW-115A and EW-7b, the monitoring data may represent only near-well conditions, with vegetable oil distribution into the formation limited. At all vegetable oil injection points, there is limited field monitoring data (pH, ORP, DO) due to the oily nature of the remaining water column. This is the case even at wells EW-14b and EW-3a, which accepted full injection volumes and follow-up chase water injections.

At EW-14b, in which the vegetable oil injection volume was performed as planned, the monitoring data to date show reducing conditions were promoted and biological degradation of chlorinated ethenes was enhanced.

Monitoring data indicate the injection of vegetable oil at MW-115A caused changes in the conditions 33 feet downgradient at MW-129A.. The sampling results for MW-115A indicate that even when the desired injection volume was not achieved, an influence in the surrounding subsurface environment may still occur.

Although MW-129A appears to be influenced by the injection at MW-115A, PCE concentrations at well MW-129A increased. While the vegetable oil injection likely created conditions more conducive to reductive dechlorination, the increased PCE concentrations may indicate there has been a change in groundwater flow patterns, or that PCE is being preferentially desorbed from the rock matrix.

Ammonia concentrations varied across the five injection points. There is apparently enough protein in the vegetable oil source that, after progressive breakdown into amino acids and then amino groups, an ammonia-nitrogen source is provided. At MW-115A and EW-7b, the ammonia concentrations rose from non-detect to over 35,000 µg/L during the pilot study. At MW-116A, EW-14b, and EW-3a, ammonia concentrations generally remained low. One explanation is that the injections at MW-115A and EW-7b clogged the filter pack and/or surrounding formation when the wells stopped accepting fluid. The clogged conditions may allow ammonia to accumulate in the well or filter pack without being dissipated into the surrounding groundwater flow.

Methane concentrations increased at all five vegetable oil injection points, especially between the January 2010 and August 2010 sampling events. The increasing levels of methane indicate methanogenic bacteria are active. Reductive dechlorination of PCE and its daughter products

typically occurs in the same environment as methanogenesis (AFCEE, 2007). Methanogenesis uses hydrogen to form methane from carbon dioxide. This hydrogen is also necessary for reductive dechlorination; thus, methanogenesis can reduce the amount of chlorinated compounds that can be degraded from the hydrogen-producing vegetable oil electron donor, although the supplemental electron donor was likely added in surplus quantity.

Data presented in EKI's report titled Summary of Results from the August 2010 In-Situ Groundwater Sampling Event Report, dated October 29, 2010, showed concentrations of 2-butanone (also known as methyl ethyl ketone or MEK) in all five wells in which vegetable oil was injected. MEK was not detected in any other wells during the August 2010 sampling event, suggesting that 2-butanone may have been present in the vegetable oil. Modern vegetable oil production from soybeans and oilseeds, including production of edible oils, is accomplished by solvent extraction. Hexane is the typical solvent, although the solvent can reportedly be allowed to contain other compounds, including 2-butanone. The solvent is boiled off, leaving the oil. Terra Systems, Inc. (the vegetable oil supplier) reports that 2-butanone has been encountered in the analytical results obtained from other sites. 2-butanone may have been a minor constituent in the extraction solvent used to create the food-grade vegetable oil injection fluid. 2-butanone is not highly toxic and is easily biodegraded.

CSIA data show enrichment of ^{12}C in TCE and cis-1,2-DCE daughter products indicating biological degradation of PCE is occurring. Significant fractionation of PCE was only observed at EW-14b. The reason for not observing fractionation is unclear and may indicate ongoing sources; or that the parent PCE has already undergone fractionation, and the enhancement of biological degradation by the supply of electron donor did not have a significant additional effect on fractionation. A range of $\delta^{13}\text{C}$ for PCE manufacturer's of approximately -37 to -24 with a mean of approximately -29 has been reported (EPA, 2008). All the CSIA results for PCE collected at the Chemplex site show a range of -25.5 to -21.6, indicating some fractionation may have already occurred prior to the injection. Only the results from EW-7b consistently had $\delta^{13}\text{C}$ values below -23.

The vegetable oil injection pilot study has demonstrated the ability of vegetable oil to provide supplemental electron donor and to promote reducing conditions, resulting in reduced concentrations of PCE and destruction of PCE mass. The pilot study encountered physical limitations such as excess vegetable oil left in the water column and potential clogging of the nearby fractures. These limitations should be taken into account for future injection events, as discussed below in Section 6.2.

5.2 PERMANGANATE INJECTION

Monitoring results from MW-108B, the permanganate injection well, showed rapid destruction of VOCs followed by rebounding of PCE concentrations. The presence of manganese was observed in MW-112A located approximately 225 feet downgradient approximately 13 months after the injection, which could indicate partial interconnection of these two wells by local bedrock fractures. The manganese observed at MW-112A has been reduced from the highly-oxidized permanganate form and is no longer active. It is unknown whether manganese solids may have precipitated in the surrounding formation.

SECTION 6.0 – CONCLUSIONS AND RECOMMENDATIONS

Vegetable oil injection successfully provided supplemental electron donor during the pilot testing, leading to reducing conditions that promoted microbial reductive dechlorination and decreased concentrations of PCE and other chlorinated ethenes. Permanganate was readily injected and produced a rapid decrease in PCE levels, although with subsequent rebound.

Both approaches offer a viable means of mitigating localized “hot spots” of PCE. Based on results of the pilot study, several recommendations for improving future application of vegetable oil or permanganate have been developed.

6.1 INJECTION LOCATIONS

During the pilot test, vegetable oil injection led to clogging and difficult sampling at certain injection points. Wells MW-115A and EW-7b, in particular, were not easily sampled in August 2010 and will need further time for the residual vegetable oil in the well casings to be distributed or to break down. Although the injection into MW-116A was halted due to decreasing injection flow rates, the well appears to be recovering due to the low volume of vegetable oil accepted by the formation at this location. Wells EW-3a and EW-14b, which readily accepted the vegetable oil injection and chase water, also exhibit vegetable oil in their water columns.

The permanganate injection does not appear to have a long-term effect on the injection point’s usefulness as a monitoring well.

6.2 IMPROVING VEGETABLE OIL INJECTION

During the pilot study’s vegetable oil injections, methods were modified and lessons learned for application to future injection efforts. The following subsections discuss observations from the pilot study to be applied to future injection activities.

6.2.1 Use a Down-Well Packer Placed Slightly Above the Well Screen

Two different styles of well casing packers were tested during the injection phase, with injection occurring below the packer location. The down-well packer was more successful than a near-surface packer. This down-hole positioning of the packer also reduces the volume of water column needing to be pushed into the formation prior to distribution of oil solution from the casing. A drill rig or similar equipment would likely be required to hoist the down-well packer, air line, and injection line, whereas a near-surface packer would be easier to insert and remove.

6.2.2 Start with Small Batches of Vegetable Oil

The stock oil solution was diluted prior to injection. Challenges with injection occurred at several wells, where the anticipated injection volume was already mixed but was not accepted by the well and surrounding formation. A series of smaller batches will reduce waste and allow

for a sufficient volume of subsequent chase water. Especially for 2-inch diameter wells, it is recommended the initial batch be no larger than 50 gallons, to allow evaluation of the injection point's acceptance of the injected volume; and to allow for chase water to be injected, if needed, prior to completion of the injection.

6.2.3 Use Available Non-Impacted Groundwater as Mix Water

For the pilot study, all mix water to create the diluted injection solution was groundwater removed from the wells into which it was injected. This is an ideal circumstance because the injected solution will have similar geochemical properties as the injection location; however, it created difficulties when wells did not accept the full injection volume because the surplus vegetable oil/water mix now had PCE in it, making its management more difficult. For this pilot study, the excess mixture was injected into well EW-3a, a former extraction well that historically showed elevated PCE concentrations. For future injections, dilution water can instead be obtained from Equistar's deep production wells, which have not been impacted by PCE.

6.2.4 Vegetable Oil Droplet Size and Viscosity

The ability to inject the anticipated volume of oil solution varied between wells. This variability likely resulted from formation conditions rather than oil droplet size. To promote ease of injection, it is recommended a lower viscosity product be used. The viscosity can be lowered by using a larger dilution factor, which will increase the total injection volume to maintain the same mass injection of vegetable oil.

6.2.5 Use Excess Chase Water

Even at injection points which accepted the injection fully (i.e., EW-3a and EW-14b), the water columns still contain residual vegetable oil. The amount of chase water injected is usually based on the dilution factor; however, for future applications, it is recommended excess chase water be used. This should allow vegetable oil to be pushed further away from the well into the formation, thereby increasing the likelihood that the injection point will be an appropriate groundwater monitoring point in a shorter timeframe.

6.2.6 Prefer Large Diameter Wells as Injection Points

The most successful injection of vegetable oil occurred at former extraction wells EW-3a and EW-14b, which are 8 inches in diameter. Physical limitations, manifested as high injection pressures and lower-than-anticipated injection volumes, were encountered at 2-inch diameter wells MW-115A and MW-116A; however, these challenges were also seen at 8-inch well EW-7b. It is unclear what role aquifer characteristics played in the injection process. Both the 2-inch wells are screened in the Lower Scotch Grove formation and EW-7b and EW-14b are both screened in the Farmers Creek stratum. EW-3a has a 30-foot screen in the highly-weathered Upper Scotch Grove formation. A larger borehole provides a larger surface area over which to distribute the vegetable oil and a higher potential to cross fractures. If vegetable oil is injected in the future, larger diameter wells should be given first consideration to increase the likelihood of successful injection.

6.3 IMPROVING PERMANGANATE INJECTION

Permanganate injection went as planned and the general procedure should be applied again to future injection events. Either Equistar production well water or groundwater pumped from the injection point could be used as dilution water. If the injection point water is employed for dilution, this will maintain the closest geochemical compatibility, and the permanganate will serve to treat the PCE and daughter products should there be a need to hold mixed solutions above grade.

To aid cleanup and potential spill response, neutralizing (reducing) agents should be kept on hand. Potential neutralization agents include citric acid, ascorbic acid, and sugar among other options.

6.4 APPLICATION OF VEGETABLE OIL OR PERMANGANATE

Either vegetable oil or permanganate can be used address localized hot spots of PCE in Chemplex site groundwater. Table 11 is an update to a table originally presented in the Work Plan, revised to include additional lessons learned during the pilot test. Permanganate has an immediate effect on PCE concentrations, but does not serve as a long-term solution and also creates an environment that is not conducive to reductive dechlorination. Vegetable oil promotes reductive dechlorination but results are typically not as rapid; however, the effect may last for two to three years in the subsurface.

For any future hot spot treatment, the reactive media should be selected based on the well location and drivers for treatment. For example, a hot spot with rapidly increasing PCE concentrations may be best addressed with permanganate. In a location with slowly rising PCE concentrations, using vegetable oil to promote microbial reductive dechlorination may be more appropriate. A longer-lasting impact will also be created. Permanganate can be applied if a rapid response is desired. It is also better able to allow the injection point to return to monitoring service.

A hybrid approach may enable the benefits of both permanganate and vegetable oil to be realized. In the hybrid approach, injection of permanganate would be followed several months later by injection of vegetable oil, thus degrading much of the chlorinated ethene mass and subsequently promoting conditions for reductive dechlorination to reduce the rebound effect.

SECTION 7.0 – REFERENCES

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TABLES

TABLE 1

**MW-115A SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-115A Vegetable Oil Injection Point	Date Event	13-May-09 Baseline	4-Aug-09 1 Month ^a	20-Oct-09 3 Month ^a	3-Nov-09 4Q PME	13-Jan-10 6 Month	25-Aug-10 12 Month
Analyte	Units						
<i>Standard Laboratory Analysis (ALS)</i>							
Perchloroethene	µg/L	3,600	-	-	1,100	1,400	1,300
Trichloroethene	µg/L	340	-	-	69	100	84 J
cis-1,2-Dichloroethene	µg/L	1,300	-	-	290	340	370
trans-1,2-Dichloroethene	µg/L	6.4	-	-	<50	<50	<100
Vinyl Chloride	µg/L	250	-	-	25 J	34 J	67 J
Chloride	mg/L	58	-	-	58	38	62
Nitrite	mg/L	<1.0	-	-	18	<1.0	<1.0
Nitrate	mg/L	9.0	-	-	2.5 J	0.36 J	1.0
Sulfate	mg/L	72	-	-	36	14	0.36
Sulfide	mg/L	<0.50	-	-	NR	NR	NR
Total Alkalinity	mg/L	280	-	-	2,100	2,000	2,300
Bicarbonate Alkalinity	mg/L	280	-	-	2,100	2,000	2,300
Carbonate Alkalinity	mg/L	<10	-	-	<10	<10	<10
Hydroxide Alkalinity	mg/L	<10	-	-	<10	<10	<10
Ammonia as N	µg/L	<50	-	-	36,000	38,000	30,000
Methane	µg/L	120	-	-	28	57	10,000
Ethane	µg/L	52	-	-	4.7	7.5	4.8
Ethene	µg/L	23	-	-	8.1	13	7.3
Iron (total)	µg/L	-	-	-	580	13,000	3,800
Iron (dissolved)	µg/L	<50	-	-	-	-	-
Manganese (total)	µg/L	-	-	-	93	5,000	18,000
Manganese (dissolved)	µg/L	2	-	-	-	-	-
Total Organic Carbon	µg/L	6,100	-	-	35,000,000	28,000,000	24,000,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>							
Perchloroethene	δ ¹³ C (‰)	-21.37	-	-	-	-	-22.43
Trichloroethene	δ ¹³ C (‰)	-19.42	-	-	-	-	-31.79
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-16.83	-	-	-	-	-21.68
Vinyl Chloride	δ ¹³ C (‰)	-22.76	-	-	-	-	-16.91
<i>Field Parameters</i>							
ORP	mV	138	-	-	-	-	-
pH	pH units	7.19	-	-	-	-	-
DO	mg/L	0	-	-	-	-	-

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

NR = Not reported. Sample color interfered with the titration method for measurement.

^a Well not sampled due to excessive vegetable oil remaining in the water column.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 2

**MW-116A SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-116A Vegetable Oil Injection Point	Date Event	13-May-09 Baseline	4-Aug-09 1 Month	20-Oct-09 3 Month	3-Nov-09 4Q PME	13-Jan-10 6 Month	12-May-10 2Q PME	25-Aug-10 12 Month
Analyte	Units							
<i>Standard Laboratory Analysis (ALS)</i>								
Perchloroethene	µg/L	870	490	620	130	49	33	19
Trichloroethene	µg/L	71	46	49	16	15	7.6	4.5
cis-1,2-Dichloroethene	µg/L	300	250	260	150	170	290	280
trans-1,2-Dichloroethene	µg/L	1.5	1.6	<5.0	<5.0	0.87	0.59 J	0.67
Vinyl Chloride	µg/L	15	26	20	13	12	7.1	6.4
Chloride	mg/L	22	28	32	39	36	-	43
Nitrite	mg/L	<1.0	<1.0	<1.0	7.5	<1.0	-	<1.0
Nitrate	mg/L	11	<0.10	0.019 J	<1.0	0.18 J	-	0.045 J
Sulfate	mg/L	52	53	0.15	2.0	0.057 J	-	0.069 J
Sulfide	mg/L	<0.50	NR	8.9	6.0	<1.0	-	NR
Total Alkalinity	mg/L	250	350	480	740	300	-	620
Bicarbonate Alkalinity	mg/L	250	350	480	740	300	-	620
Carbonate Alkalinity	mg/L	<10	<10	<10	<10	<10	-	<10
Hydroxide Alkalinity	mg/L	<10	<10	<10	<10	<10	-	<10
Ammonia as N	µg/L	<50	210 J	96	37	79	-	27
Methane	µg/L	11	38	44	230	4,100	-	8,400
Ethane	µg/L	9.6 J	16	2.9	3.3	3.1	-	<2
Ethene	µg/L	7.7 J	11	7.3	4.3	4.5	-	<1
Iron (total)	µg/L	1,000	3,400	25,000	77,000	93,000	-	73,000
Iron (dissolved)	µg/L	<50	350	35,000	84,000	110,000	-	77,000
Manganese (total)	µg/L	33	870	1,700	3600	3,000	-	1,100
Manganese (dissolved)	µg/L	12	420	2,200	3,700	3,000	-	1,100
Total Organic Carbon	µg/L	1,200	540,000	870,000	770,000	820,000	-	370,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>								
Perchloroethene	δ ¹³ C (‰)	-21.18	-	-22.27	-	-	-	-21.11
Trichloroethene	δ ¹³ C (‰)	-19.94	-	-32.29	-	-	-	-19.32
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-15.76	-	-18.18	-	-	-	-18.69
Vinyl Chloride	δ ¹³ C (‰)	ND	-	ND	-	-	-	-26.26
<i>Field Parameters</i>								
ORP	mV	-4	-	-	-83	-90	-	-98
pH	pH units	7.16	-	-	6.75	5.65	-	6.02
DO	mg/L	0.0	-	-	8.20 ^a	10.34 ^a	-	4.96 ^a

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

NR = Not reported. Sample color interfered with the titration method for measurement.

ND = Laboratory did not find sufficient concentrations to perform isotope analysis.

^a Sample was filtered prior to measuring DO, which likely biased this result upward.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 3
EW-7b SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA

EW-7b Vegetable Oil Injection Point	Date Event	13-May-09 Baseline	4-Aug-09 1 Month ^a	21-Oct-09 3 Month	3-Nov-09 4Q PME	14-Jan-10 6 Month	26-Aug-10 12 Month
Analyte	Units						
<i>Standard Laboratory Analysis (ALS)</i>							
Perchloroethene	µg/L	270	-	59	64	73	380
Trichloroethene	µg/L	17	-	3.3 J	<50	<13	<100
cis-1,2-Dichloroethene	µg/L	12	-	3.4 J	<50	7.4 J	<100
trans-1,2-Dichloroethene	µg/L	<0.50	-	<5.0	<50	<13	<100
Vinyl Chloride	µg/L	<0.50	-	<5.0	<50	<13	<100
Chloride	mg/L	2.3	-	4.3	-	4.9	7.6
Nitrite	mg/L	<0.10	-	<1.0	-	<1.0	<1.0
Nitrate	mg/L	4.2	-	0.36 J	-	<1.0	8.9 J
Sulfate	mg/L	14	-	0.47 J	-	0.17	0.23
Sulfide	mg/L	<1.0	-	NR	-	NR	<1.0
Total Alkalinity	mg/L	270	-	1,200	-	1,700	1,600
Bicarbonate Alkalinity	mg/L	270	-	1,200	-	1,700	1,600
Carbonate Alkalinity	mg/L	<10	-	<10	-	<10	<10
Hydroxide Alkalinity	mg/L	<10	-	<10	-	<10	<10
Ammonia as N	µg/L	<50	-	19,000	-	36,000	31,000
Methane	µg/L	6.2	-	40	-	2,400	16,000
Ethane	µg/L	7.7 J	-	2.1	-	5.5	4.0
Ethene	µg/L	7.5 J	-	1.1	-	1.1	1.3
Iron (total)	µg/L	53	-	2,000	-	97,000	230,000
Iron (dissolved)	µg/L	<50	-	1,800	-	-	-
Manganese (total)	µg/L	2 J	-	170	-	2,400	4,500
Manganese (dissolved)	µg/L	1.6 J	-	160	-	-	-
Total Organic Carbon	µg/L	650	-	17,000,000	-	17,000,000	14,000,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>							
Perchloroethene	δ ¹³ C (‰)	-25.50	-	-25.03	-	-	-25.26
Trichloroethene	δ ¹³ C (‰)	-28.05	-	ND	-	-	-35.98
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-26.07	-	ND	-	-	ND
Vinyl Chloride	δ ¹³ C (‰)	ND	-	ND	-	-	-35.61
<i>Field Parameters</i>							
ORP	mV	99	-	-	-	-	-
pH	pH units	7.56	-	-	-	-	-
DO	mg/L	0.67	-	-	-	-	-

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

NR = Not reported. Sample color interfered with the titration method for measurement.

ND = Laboratory did not find sufficient concentrations to perform isotope analysis.

^a Well not sampled due to excessive vegetable oil remaining in the water column.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 4

EW-14b SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA

EW-14b Vegetable Oil Injection Point	Date Event	12-May-09 Baseline	4-Aug-09 1 Month	21-Oct-09 3 Month	14-Jan-10 6 Month	26-Aug-10 12 Month
Analyte	Units					
<i>Standard Laboratory Analysis (ALS)</i>						
Perchloroethene	µg/L	990	460	160	3.2	7.0
Trichloroethene	µg/L	99	43	27	1.5	0.42 J
cis-1,2-Dichloroethene	µg/L	310	210	460	490	320
trans-1,2-Dichloroethene	µg/L	2.0	1.3	<5.0	1.1	0.63
Vinyl Chloride	µg/L	36	38	30	28	20
Chloride	mg/L	16	18	2.7	15	18
Nitrite	mg/L	<1.0	<1.0	<0.10	<1.0	<1.0
Nitrate	mg/L	8.3	0.12 J	<0.10	<1.0	0.039 J
Sulfate	mg/L	27	26	0.16	0.18	0.11
Sulfide	mg/L	<1.0	NR	<1.0	<1.0	<1.0
Total Alkalinity	mg/L	260	290	900	1,200	750
Bicarbonate Alkalinity	mg/L	260	290	900	1,200	750
Carbonate Alkalinity	mg/L	<10	<10	<10	<10	<10
Hydroxide Alkalinity	mg/L	<10	<10	<10	<10	<10
Ammonia as N	µg/L	65	840	<50	6,200	<50
Methane	µg/L	83	120	71	2,000	13,000
Ethane	µg/L	24	62	6.7	12	<2
Ethene	µg/L	13	46	9.9	9.5	<1
Iron (total)	µg/L	63	930	7,600	17,000	4,200
Iron (dissolved)	µg/L	<50	940	6,900	16,000	3,700
Manganese (total)	µg/L	57	160	2,900	12,000	890
Manganese (dissolved)	µg/L	65	170	2,900	11,000	810
Total Organic Carbon	µg/L	1,400	2,000,000	930,000	1,300,000	320,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>						
Perchloroethene	δ ¹³ C (‰)	-21.62	-	-18.68	-	ND
Trichloroethene	δ ¹³ C (‰)	-19.61	-	-20.69	-	ND
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-14.62	-	-20.04	-	-16.97
Vinyl Chloride	δ ¹³ C (‰)	-19.81	-	-20.76	-	-17.34
<i>Field Parameters</i>						
ORP	mV	93	-	-	-22	-
pH	pH units	7.55	-	-	5.64	-
DO	mg/L	0.20	-	-	7.60 ^a	-

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

ND = Laboratory did not find sufficient concentrations to perform isotope analysis.

NR = Not reported. Sample color interfered with the titration method for measurement.

^a Sample was filtered prior to measuring DO, which likely biased this result upward.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 5

**EW-3a SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

EW-3a Vegetable Oil Injection Point	Date Event	25-May-99 Baseline	4-Aug-09 1 Month ^b	21-Oct-09 3 Month ^b	14-Jan-10 6 Month	26-Aug-10 12 Month
Analyte	Units					
<i>Standard Laboratory Analysis (ALS^a)</i>						
Perchloroethene	µg/L	8,100	-	-	200	40
Trichloroethene	µg/L	1,200	-	-	22	8
cis-1,2-Dichloroethene	µg/L	1,300	-	-	180	100
trans-1,2-Dichloroethene	µg/L	<500	-	-	<25	<2.5
Vinyl Chloride	µg/L	<500	-	-	<25	3.9
Chloride	mg/L	-	-	-	31	39
Nitrite	mg/L	-	-	-	<1.0	<1.0
Nitrate	mg/L	-	-	-	<1.0	7.2 J
Sulfate	mg/L	-	-	-	0.58	0.17
Sulfide	mg/L	-	-	-	NR	<1.0
Total Alkalinity	mg/L	-	-	-	220	510
Bicarbonate Alkalinity	mg/L	-	-	-	220	510
Carbonate Alkalinity	mg/L	-	-	-	<10	<10
Hydroxide Alkalinity	mg/L	-	-	-	<10	<10
Ammonia as N	µg/L	-	-	-	790	50
Methane	µg/L	-	-	-	330	19,000
Ethane	µg/L	-	-	-	14	3.7
Ethene	µg/L	-	-	-	2.3	2.6
Iron (total)	µg/L	-	-	-	120,000	43,000
Iron (dissolved)	µg/L	-	-	-	-	38,000
Manganese (total)	µg/L	-	-	-	8,800	1,400
Manganese (dissolved)	µg/L	-	-	-	-	1,300
Total Organic Carbon	µg/L	-	-	-	5,000,000	1,300,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>						
Perchloroethene	δ ¹³ C (‰)	-	-	-	-	-
Trichloroethene	δ ¹³ C (‰)	-	-	-	-	-
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-	-	-	-	-
Vinyl Chloride	δ ¹³ C (‰)	-	-	-	-	-
<i>Field Parameters</i>						
ORP	mV	-	-	-	-	-
pH	pH units	7.17	-	-	-	-
DO	mg/L	3.24	-	-	-	-

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

NR = Not reported. Sample color interfered with the titration method for measurement.

^a 1999 analysis not performed by ALS.^b Well not sampled due to excessive vegetable oil remaining in the water column.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 6

**MW-108B SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-108B Permanganate Injection Point	Date Event	12-May-09 Baseline	4-Aug-09 1 Month	21-Oct-09 3 Month	4-Nov-09 4Q PME	13-Jan-10 6 Month	12-May-10 2Q PME	25-Aug-10 12 Month
Analyte	Units							
<i>Standard Laboratory Analysis (ALS)</i>								
Perchloroethene	µg/L	350	<0.50	14	43	210	260	250
Trichloroethene	µg/L	21	<0.50	<0.50	<0.50	<0.50	14	17
cis-1,2-Dichloroethene	µg/L	110	<0.50	<0.50	<0.50	<0.50	61	78
trans-1,2-Dichloroethene	µg/L	0.52	<0.50	<0.50	<0.50	<0.50	0.3 J	0.32 J
Vinyl Chloride	µg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chloride	mg/L	28	61	31	-	33	-	35
Nitrite	mg/L	<1.0	<1.0	<1.0	-	<1.0	-	<1.0
Nitrate	mg/L	22	20	14	-	15	-	11
Sulfate	mg/L	40	58	36	-	38	-	34
Sulfide	mg/L	<0.50	NR	NR	-	NR	-	<1.0
Total Alkalinity	mg/L	260	270	250	-	270	-	260
Bicarbonate Alkalinity	mg/L	260	270	250	-	270	-	260
Carbonate Alkalinity	mg/L	<10	<10	<10	-	<10	-	<10
Hydroxide Alkalinity	mg/L	<10	<10	<10	-	<10	-	<10
Ammonia as N	µg/L	<50	280 J	26 J	-	<50	-	<50
Methane	µg/L	3 J	5.1 J	<1	-	<1	-	<1
Ethane	µg/L	<11	7 J	<2	-	<2	-	<2
Ethene	µg/L	<9.9	6.8 J	<1	-	<1	-	<1
Iron (total)	µg/L	42 J	3,000	230	-	<230	-	<100
Iron (dissolved)	µg/L	<50	2,400 J	<230	-	<230	-	<100
Manganese (total)	µg/L	2 J	700,000	25,000	-	2,400	-	38
Manganese (dissolved)	µg/L	<10	510,000	22,000	-	1,900	-	<10
Total Organic Carbon	µg/L	740 J	71,000	1,300	-	970 J	-	690
<i>Compound Specific Isotope Analysis (Microseeps)</i>								
Perchloroethene	δ ¹³ C (‰)	-22.75	-	ND	-	-	-	-23.09
Trichloroethene	δ ¹³ C (‰)	-21.66	-	ND	-	-	-	-22.42
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-17.00	-	ND	-	-	-	-18.84
Vinyl Chloride	δ ¹³ C (‰)	ND	-	ND	-	-	-	ND
<i>Field Parameters</i>								
ORP	mV	-1	431	-	52.6	444	456	173
pH	pH units	7.06	7.1	-	7.27	7.48	6.80	7.04
DO	mg/L	2	7.23	-	2.66	11.09	10.8	3.44

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

NR = Not reported. Sample color interfered with the titration method for measurement.

ND = Laboratory did not find sufficient concentrations to perform isotope analysis.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 7

**MW-109B SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-109B Downgradient Monitoring Point	Date Event	12-May-09 Baseline	4-Aug-09 1 Month	20-Oct-09 3 Month	3-Nov-09 4Q PME	13-Jan-10 6 Month	11-May-10 2Q PME	25-Aug-10 12 Month
Analyte	Units							
<i>Standard Laboratory Analysis (ALS)</i>								
Perchloroethene	µg/L	420	500	440	450	340	630	380
Trichloroethene	µg/L	16	19	18	21	18	22	17
cis-1,2-Dichloroethene	µg/L	71	79	73	88	81	90	74
trans-1,2-Dichloroethene	µg/L	0.3	0.25 J	0.33 J	0.29 J	0.29 J	0.44 J	<1.0
Vinyl Chloride	µg/L	<0.50	<0.50	<0.50	0.22 J	0.24 J	<0.50	<1.0
Chloride	mg/L	7.0	7.7	7.3	6.6	7.4	-	8.0
Nitrite	mg/L	<0.10	<0.10	<0.10	0.7 J	<1.0	-	<0.1
Nitrate	mg/L	18	19	18	18	20	-	19
Sulfate	mg/L	31	34	31	30	32	-	31
Sulfide	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0
Total Alkalinity	mg/L	240	230	230	210	240	-	230
Bicarbonate Alkalinity	mg/L	240	230	230	210	240	-	230
Carbonate Alkalinity	mg/L	<10	<10	<10	<10	<10	-	<10
Hydroxide Alkalinity	mg/L	<10	<10	<10	<10	<10	-	<10
Ammonia as N	µg/L	<50	<50	<50	<50	<50	-	<50
Methane	µg/L	6.3	18	<1	<1	<1	-	<1
Ethane	µg/L	6.9 J	22	<2	<2	<2	-	<2
Ethene	µg/L	7 J	19	<1	<1	<1	-	<1
Iron (total)	µg/L	<50	<50	<50	27 J	<50	-	<100
Iron (dissolved)	µg/L	<50	<50	<50	<50	<50	-	<100
Manganese (total)	µg/L	1 J	<10	<10	<10	<10	-	<10
Manganese (dissolved)	µg/L	<10	<10	<10	<10	<10	-	<10
Total Organic Carbon	µg/L	<1,000	1,300	<1,000	700 J	<1,000	-	<2,000
<i>Compound Specific Isotope Analysis (Microseeps)</i>								
Perchloroethene	δ ¹³ C (‰)	-21.82	-	-22.11	-	-	-	-23.09
Trichloroethene	δ ¹³ C (‰)	-20.41	-	-21.17	-	-	-	-21.68
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-18.80	-	-18.62	-	-	-	-19.21
Vinyl Chloride	δ ¹³ C (‰)	ND	-	ND	-	-	-	ND
<i>Field Parameters</i>								
ORP	mV	120	213	86	227	74	288	281
pH	pH units	7.53	6.61	6.99	7.06	7.26	7.17	7.01
DO	mg/L	6.51	7.61	7.79	7.16	8.09	11.21	12.83

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 8

**MW-129A SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-129A Downgradient Monitoring Point	Date Event	13-May-09 Baseline	4-Aug-09 1 Month	20-Oct-09 3 Month	3-Nov-09 4Q PME	13-Jan-10 6 Month	12-May-10 2Q PME	25-Aug-10 12 Month
Analyte	Units							
<i>Standard Laboratory Analysis (ALS)</i>								
Perchloroethene	µg/L	1,000	2,900	3,000	3,400	2,700	3,800	4,200
Trichloroethene	µg/L	120	250	230	270	230	270	290
cis-1,2-Dichloroethene	µg/L	500	930	840	980	920	1,000	1,200
trans-1,2-Dichloroethene	µg/L	2.8	5.1	4.2	5.8	5.8	6.1	5.5
Vinyl Chloride	µg/L	78	230	190	220	200	210	250
Chloride	mg/L	28	39	39	-	42	-	45
Nitrite	mg/L	0.71 J	<1.0	0.33 J	-	<1.0	-	<1.0
Nitrate	mg/L	11	5.3	5.5	-	5.7	-	7.0
Sulfate	mg/L	58	68	63	-	64	-	63
Sulfide	mg/L	<0.50	<1.0	<1.0	-	<1.0	-	<1.0
Total Alkalinity	mg/L	300	260	260	-	270	-	270
Bicarbonate Alkalinity	mg/L	300	260	260	-	270	-	270
Carbonate Alkalinity	mg/L	<10	<10	<10	-	<10	-	<10
Hydroxide Alkalinity	mg/L	<10	<10	<10	-	<10	-	<10
Ammonia as N	µg/L	<50	<250	<50	-	73	-	<50
Methane	µg/L	13	240	350	-	290	-	440
Ethane	µg/L	13	62	17	-	16	-	25
Ethene	µg/L	8.8 J	16	86	-	74	-	110
Iron (total)	µg/L	-	6,100	2,300	-	640	-	2,500
Iron (dissolved)	µg/L	<50	<50	210	-	130	-	58 J
Manganese (total)	µg/L	-	200	140	-	83	-	72
Manganese (dissolved)	µg/L	14	120	122	-	69	-	56
Total Organic Carbon	µg/L	2,100	6,000	4,100	-	4,200	-	4,500
<i>Compound Specific Isotope Analysis (Microseeps)</i>								
Perchloroethene	δ ¹³ C (‰)	-21.82	-	-22.14	-	-	-	-22.26
Trichloroethene	δ ¹³ C (‰)	-19.49	-	-20.28	-	-	-	-21.25
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-15.65	-	-16.65	-	-	-	-16.83
Vinyl Chloride	δ ¹³ C (‰)	-20.04	-	-21.11	-	-	-	-23.70
<i>Field Parameters</i>								
ORP	mV	178	132	-126	-77	-113	-62	-90
pH	pH units	7.22	7.74	6.82	7.29	7.11	6.83	6.97
DO	mg/L	0	2.07	2.2	1.06	1.93	0.32	0.81

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 9

**MW-112A SAMPLING RESULTS
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

MW-112A Downgradient Monitoring Point	Date Event	15-Apr-08 Baseline	4-Aug-09 1 Month	21-Oct-09 3 Month ^a	3-Nov-09 4Q PME	14-Jan-10 6 Month	12-May-10 2Q PME	25-Aug-10 12 Month
Analyte	Units							
<i>Standard Laboratory Analysis (ALS^a)</i>								
Perchloroethene	µg/L	800	610	-	540	560	640	650
Trichloroethene	µg/L	43	36	-	37	36	29	32
cis-1,2-Dichloroethene	µg/L	240	200	-	200	170	170	190
trans-1,2-Dichloroethene	µg/L	<5	0.44 J	-	0.47 J	0.58	2.2	<1.0
Vinyl Chloride	µg/L	<5	<1.0	-	<1.0	0.29 J	<1.0	<1.0
Chloride	mg/L	-	27	-	26	29	-	30
Nitrite	mg/L	-	<1.0	-	1.4	<1.0	-	<1.0
Nitrate	mg/L	-	14	-	13	14	-	14
Sulfate	mg/L	-	50	-	45	45	-	47
Sulfide	mg/L	-	<1.0	-	<1.0	<1.0	-	<1.0
Total Alkalinity	mg/L	-	270	-	280	280	-	280
Bicarbonate Alkalinity	mg/L	-	270	-	280	280	-	280
Carbonate Alkalinity	mg/L	-	<10	-	<10	<10	-	<10
Hydroxide Alkalinity	mg/L	-	<10	-	<10	<10	-	<10
Ammonia as N	µg/L	-	<50	-	<50	<50	-	<50
Methane	µg/L	-	9.2	-	<1	<1	-	<1
Ethane	µg/L	-	8 J	-	<2	<2	-	<2
Ethene	µg/L	-	7.2 J	-	<1	<1	-	<1
Iron (total)	µg/L	-	210	-	220	82	-	180
Iron (dissolved)	µg/L	-	50	-	<50	42 J	-	180
Manganese (total)	µg/L	-	9.5 J	-	9.2 J	2.7 J	-	38
Manganese (dissolved)	µg/L	-	<10	-	<10	2.5 J	-	7.6
Total Organic Carbon	µg/L	-	1,000	-	940 J	720 J	-	680 J
<i>Compound Specific Isotope Analysis (Microseeps)</i>								
Perchloroethene	δ ¹³ C (‰)	-	-	-	-22.43	-	-	-23.52
Trichloroethene	δ ¹³ C (‰)	-	-	-	-21.4	-	-	-22.25
cis-1,2-Dichloroethene	δ ¹³ C (‰)	-	-	-	-17.29	-	-	-18.42
Vinyl Chloride	δ ¹³ C (‰)	-	-	-	ND	-	-	ND
<i>Field Parameters</i>								
ORP	mV	248	141	-	91	64	251	100
pH	pH units	7.23	6.92	-	7.30	7.10	6.75	6.96
DO	mg/L	0	4.16	-	3.53	3.21	2.35	7.43

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

mV = Millivolts.

4Q = Fourth quarter.

ALS = Analysis performed by ALS Laboratory Group.

Microseeps = Analysis performed by Microseeps, Inc.

δ¹³C (‰) = Delta carbon 13 ratio.

J = Result is less than reporting limit but greater than method detection limit.

PME = Performance Monitoring Evaluation sampling event.

- = Not sampled or analyzed.

^a 3-Month sample was not collected. Instead, well was sampled during the 4Q 2009 PME event.

DO = Dissolved oxygen.

N = Nitrogen.

ORP = Oxidation reduction potential.

< = Less than.

TABLE 10

**SUMMARY OF CSIA DATA
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

Location	Activity	Compound	$\delta^{13}\text{C}$ (‰)			Change In $\delta^{13}\text{C}$ (‰)		
			May-09 Baseline	Oct-09 3-Month	Aug-10 12-Month	Baseline and 3-Month	3-Month and 12-Month	Baseline and 12-Month
MW-115A	Vegetable Oil Injection	PCE	-21.37	-	-22.43	NC	NC	-1.06
		TCE	-19.42	-	-31.79	NC	NC	-12.37
		cis-1,2-DCE	-16.83	-	-21.68	NC	NC	-4.85
		VC	-22.76	-	-16.91	NC	NC	5.85
MW-116A	Vegetable Oil Injection	PCE	-21.18	-22.27	-21.11	-1.09	1.16	0.07
		TCE	-19.94	-32.29	-19.32	-12.35	12.97	0.62
		cis-1,2-DCE	-15.76	-18.18	-18.69	-2.42	-0.51	-2.93
		VC	-	-	-26.26	NC	NC	NC
EW-7b	Vegetable Oil Injection	PCE	-25.50	-25.03	-25.26	0.47	-0.23	0.24
		TCE	-28.05	-	-35.98	NC	NC	-7.93 ^a
		cis-1,2-DCE	-26.07	-	-	NC	NC	NC
		VC	-	-	-35.61	NC	NC	NC
EW-14b	Vegetable Oil Injection	PCE	-21.62	-18.68	-	2.94	NC	NC
		TCE	-19.61	-20.69	-	-1.08	NC	NC
		cis-1,2-DCE	-14.62	-20.04	-16.97	-5.42	3.07	-2.35
		VC	-19.81	-20.76	-17.34	-0.95	3.42	2.47
MW-108B	Permanganate Injection	PCE	-22.75	-	-23.09	NC	NC	-0.34
		TCE	-21.66	-	-22.42	NC	NC	-0.76
		cis-1,2-DCE	-17.00	-	-18.84	NC	NC	-1.84
		VC	-	-	-	NC	NC	NC

TABLE 10

**SUMMARY OF CSIA DATA
HOT SPOT PILOT STUDY
CHEMPLEX SITE - CLINTON, IOWA**

Location	Activity	Compound	$\delta^{13}\text{C}$ (‰)			Change In $\delta^{13}\text{C}$ (‰)		
			May-09 Baseline	Oct-09 3-Month	Aug-10 12-Month	Baseline and 3-Month	3-Month and 12-Month	Baseline and 12-Month
MW-109B	Vegetable Oil Monitoring	PCE	-21.82	-22.11	-23.09	-0.29	-0.98	-1.27
		TCE	-20.41	-21.17	-21.68	-0.76	-0.51	-1.27
		cis-1,2-DCE	-18.80	-18.62	-19.21	0.18	-0.59	-0.41
		VC	-	-	-	NC	NC	NC
MW-129A	Vegetable Oil	PCE	-21.82	-22.14	-22.26	-0.32	-0.12	-0.44
		TCE	-19.49	-20.28	-21.25	-0.79	-0.97	-1.76
		cis-1,2-DCE	-15.65	-16.65	-16.83	-1.00	-0.18	-1.18
		VC	-20.04	-21.11	-23.70	-1.07	-2.59	-3.66
MW-112A	Permanganate Monitoring	PCE	-	-22.43	-23.52	NC	-1.09	NC
		TCE	-	-21.40	-22.25	NC	-0.85	NC
		cis-1,2-DCE	-	-17.29	-18.42	NC	-1.13	NC
		VC	-	-	-	NC	NC	NC

Notes:

CSIA = Compound-specific isotope analysis.

PCE = Perchloroethene.

TCE = Trichloroethene.

cis-1,2-DCE = cis-1,2-Dichloroethene.

VC = Vinyl chloride.

- = No sample result. Either compound was not detected or no sample was collected.

$\delta^{13}\text{C}$ (‰) = Delta carbon 13 ratio.

NC = Not calculated.

^a ALS reported no detection of TCE, with a reporting limit of 100 micrograms per liter.

< = Less than.

TABLE 11

**COMPARISON OF VEGETABLE OIL AND PERMANGANATE
CHEMPLEX SITE - CLINTON, IOWA**

Characteristic	Chemical Oxidation	Electron Donor
Active Injectate	Permanganate and possible pH buffers/catalysts.	Vegetable oil and possible nutrients/vitamins.
Contaminant Mass Reduction Mechanism	Direct oxidation of chlorinated compounds and other organic compounds.	Enhances biological dechlorination.
Feasibility	High, extensive use, multiple vendors. Well demonstrated.	High, food-grade injection, multiple vendors. Well demonstrated.
Advantages	Direct treatment of PCE and daughter products.	Long lasting.
	Demonstrated injection and efficacy at Chemplex site.	Enhancement of natural processes.
	Quick results observable.	Demonstrated some injection and chemical treatment success at Chemplex site.
Drawbacks/Concerns	Reduces microbial community slowing natural attenuation processes.	Slower degradation reaction.
	Mobilization of some metals (chromium, selenium).	Possible incomplete treatment.
	Manganese oxide precipitates may clog pore spaces.	Potential mobilization of some metals.
	Rebounding concentrations observed six months after injection at Chemplex site.	Possible clogging of well screen/formation during injection.

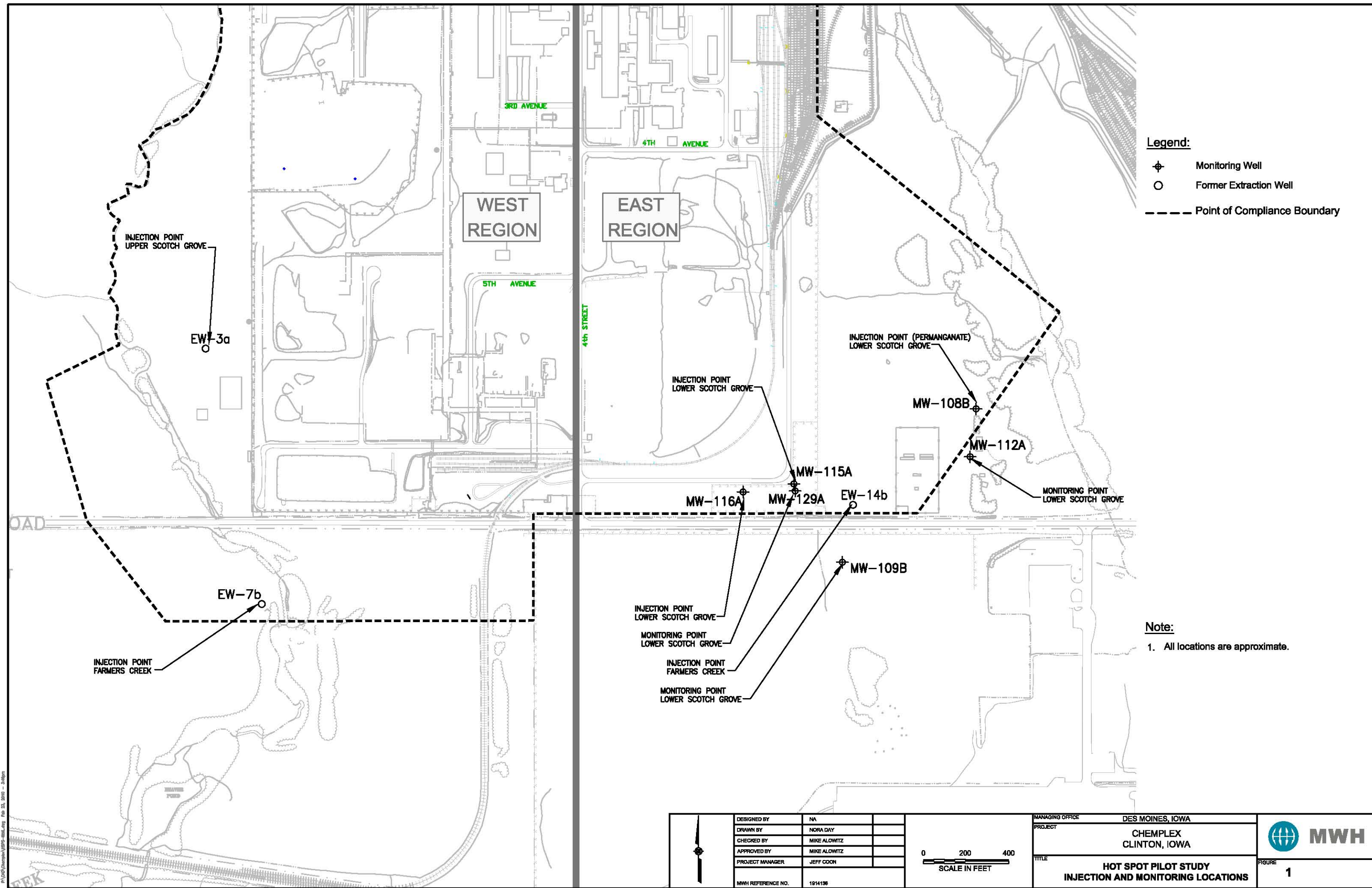
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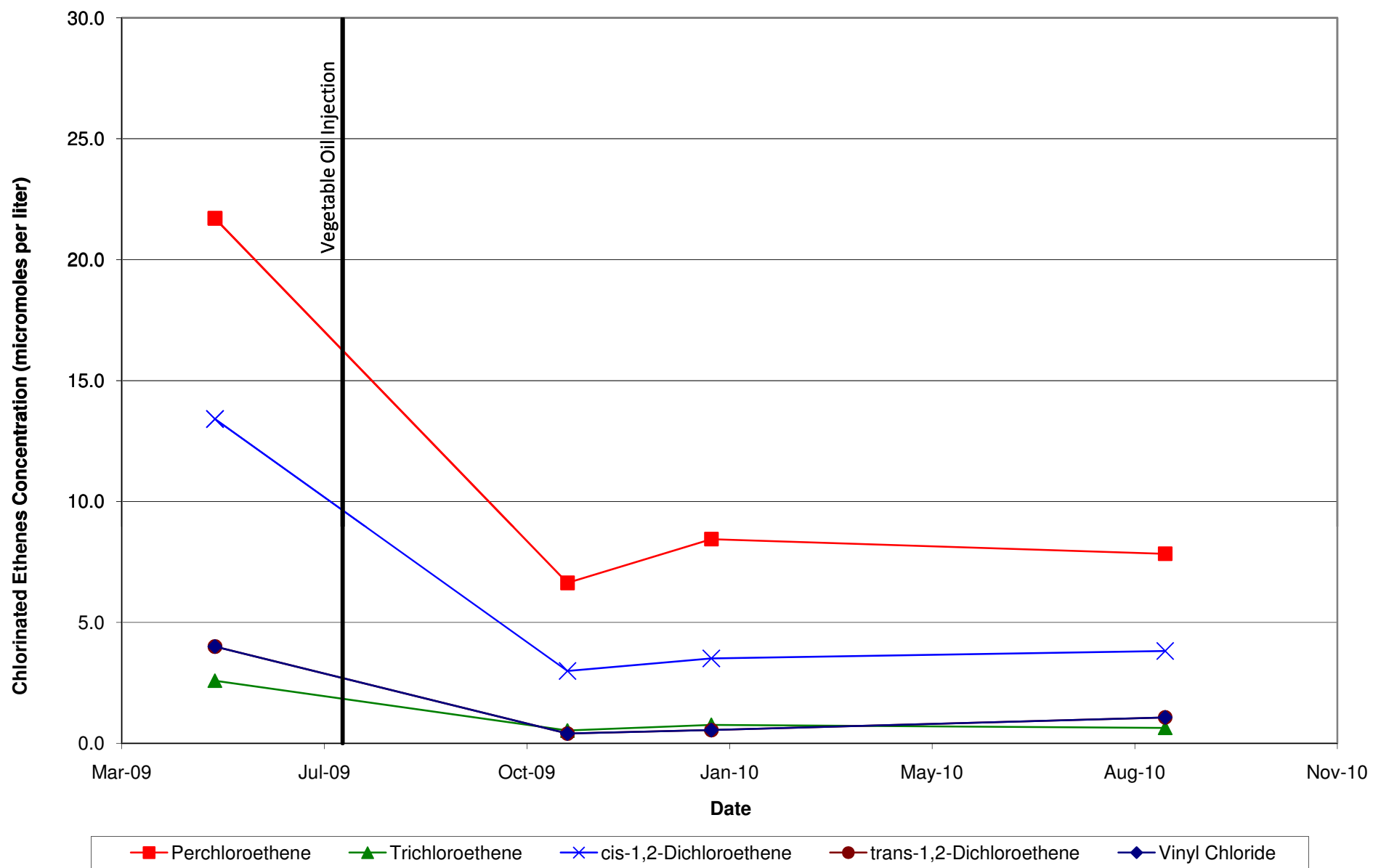
PCE = Perchloroethene.

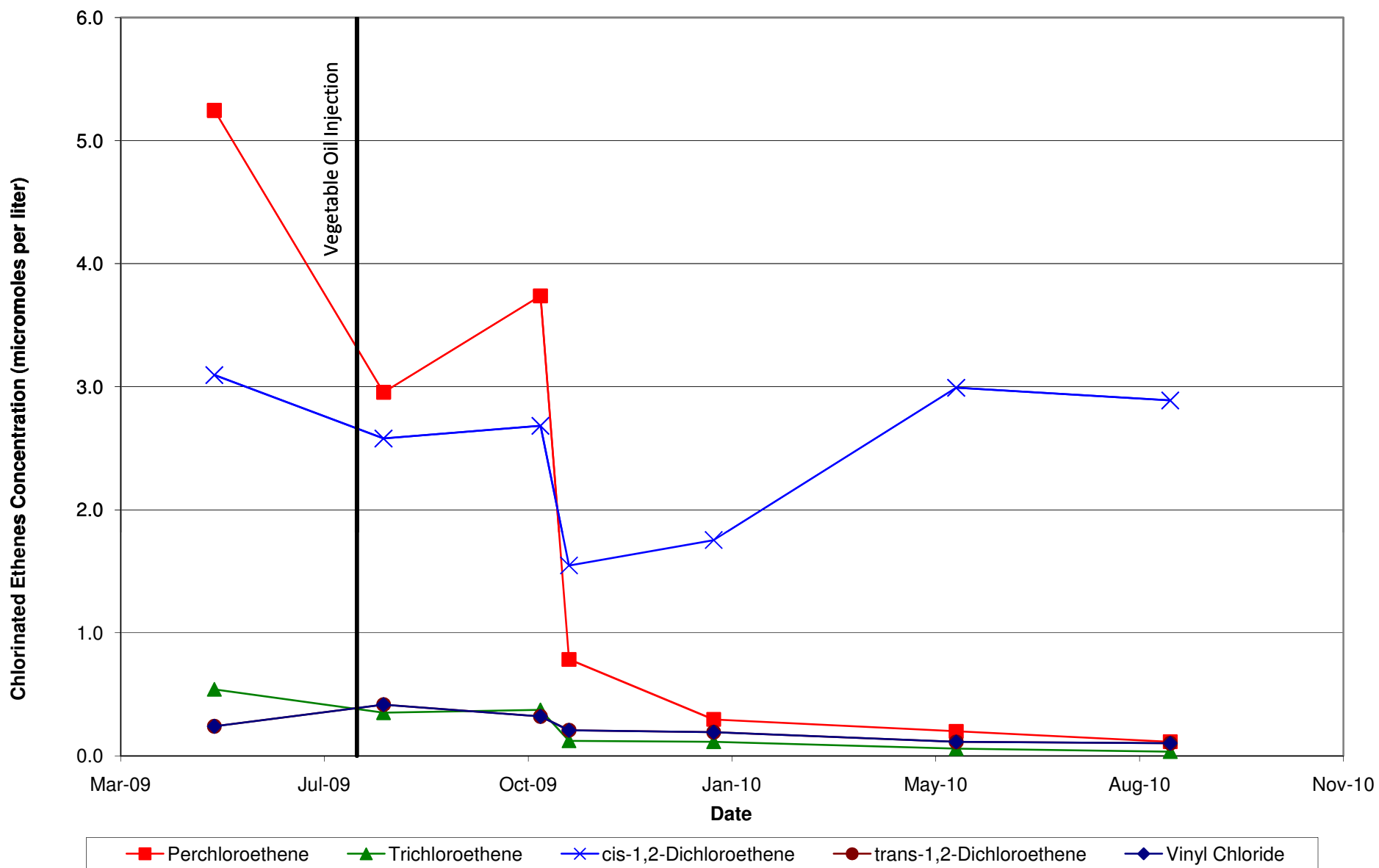
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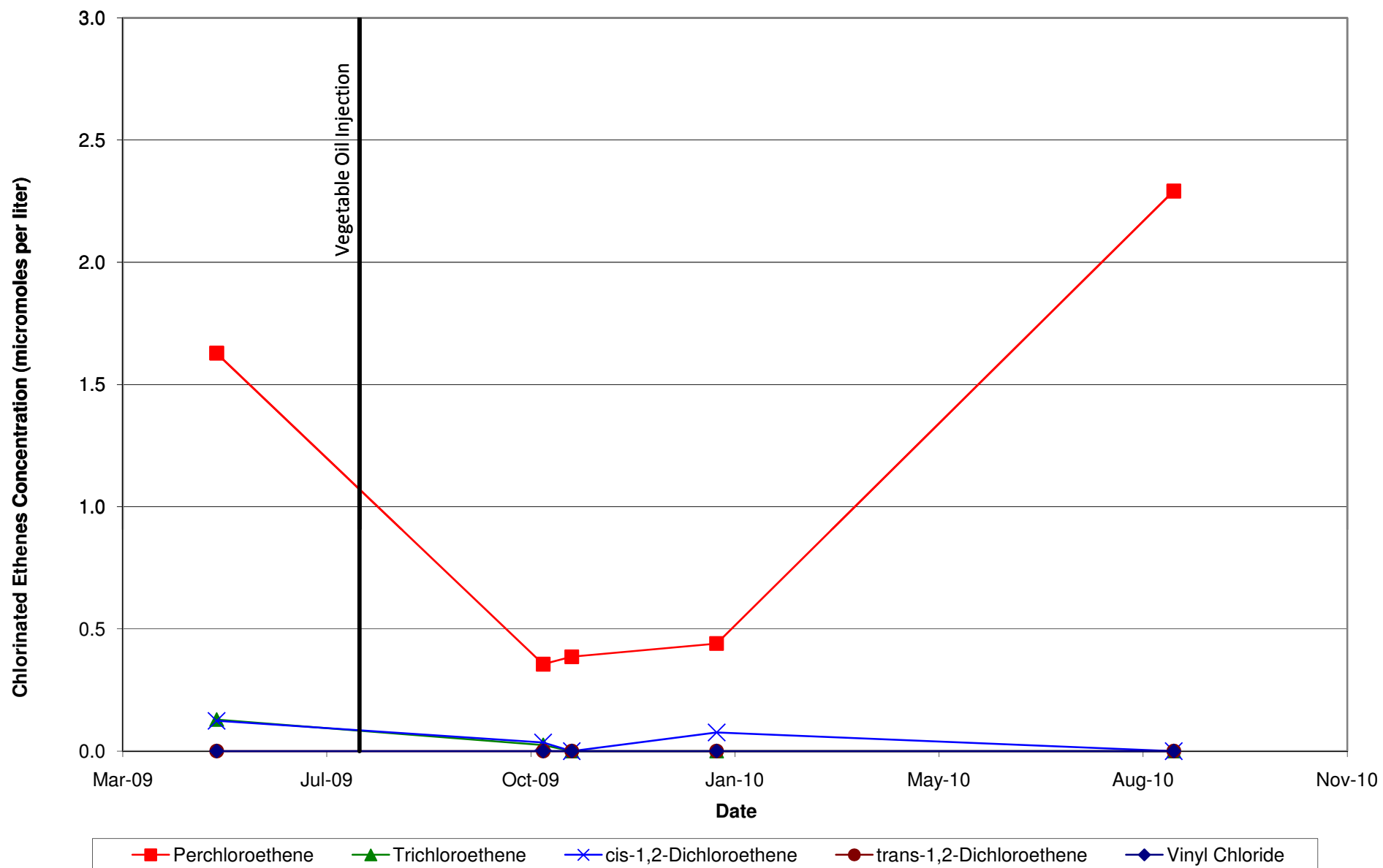


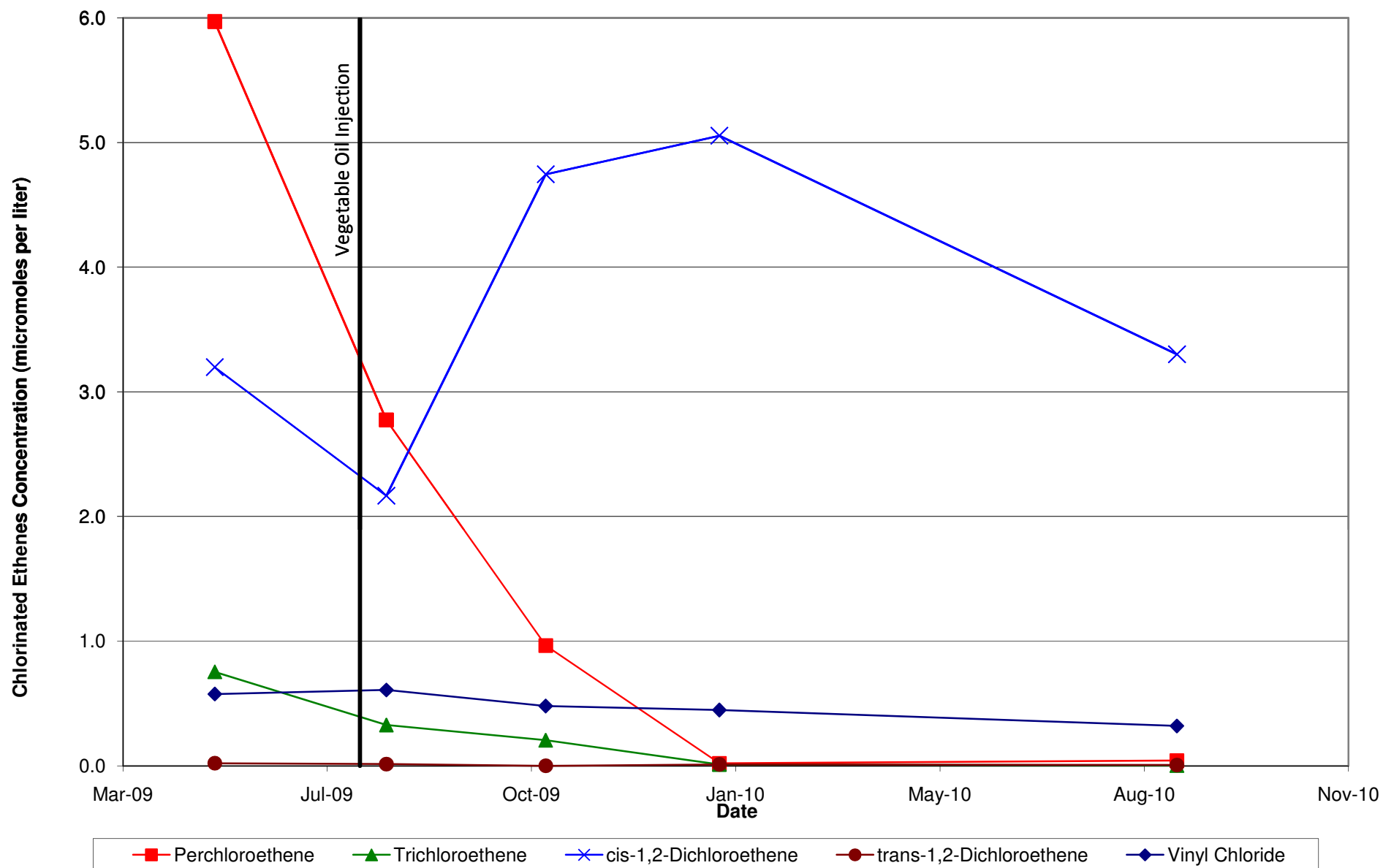
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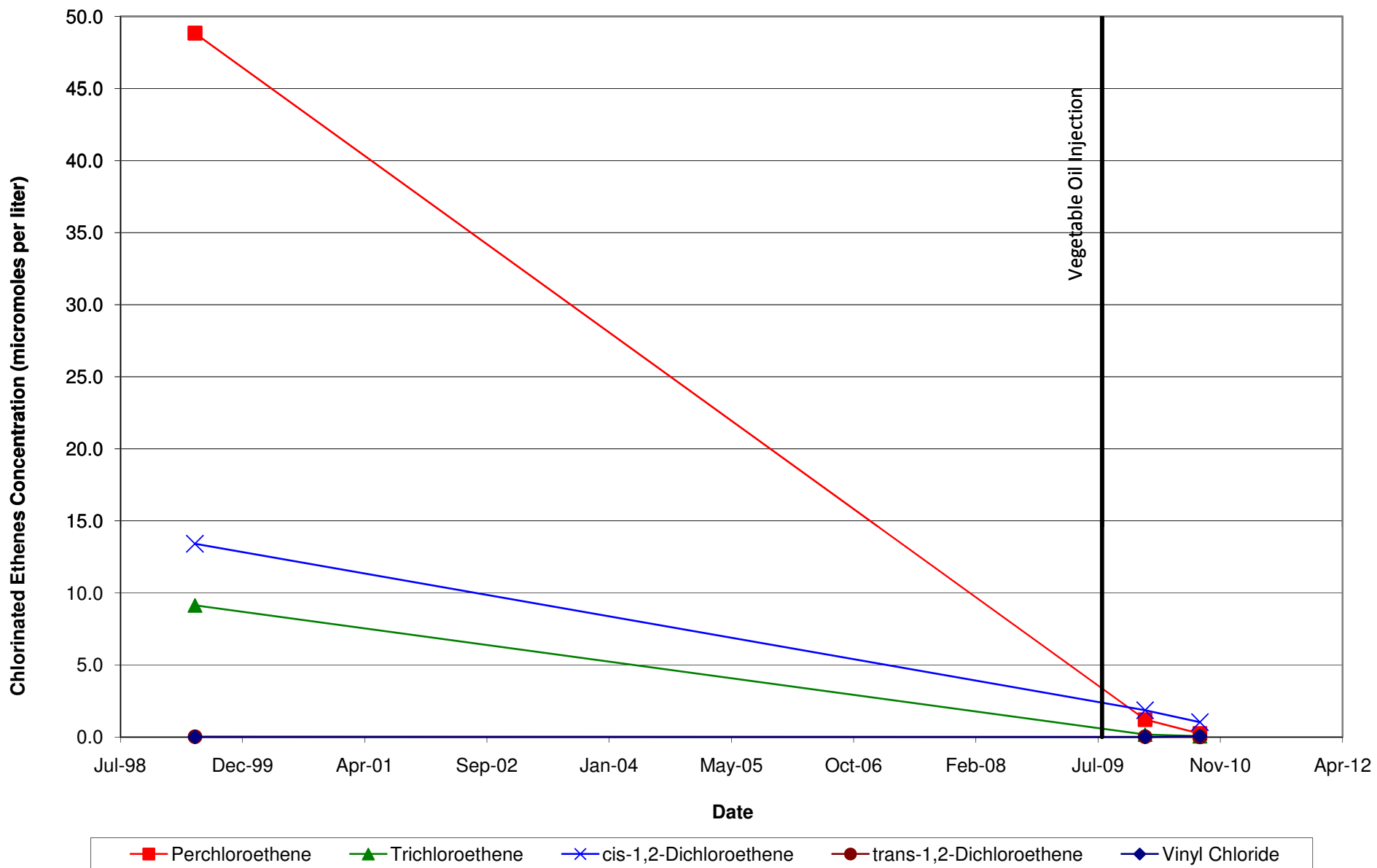


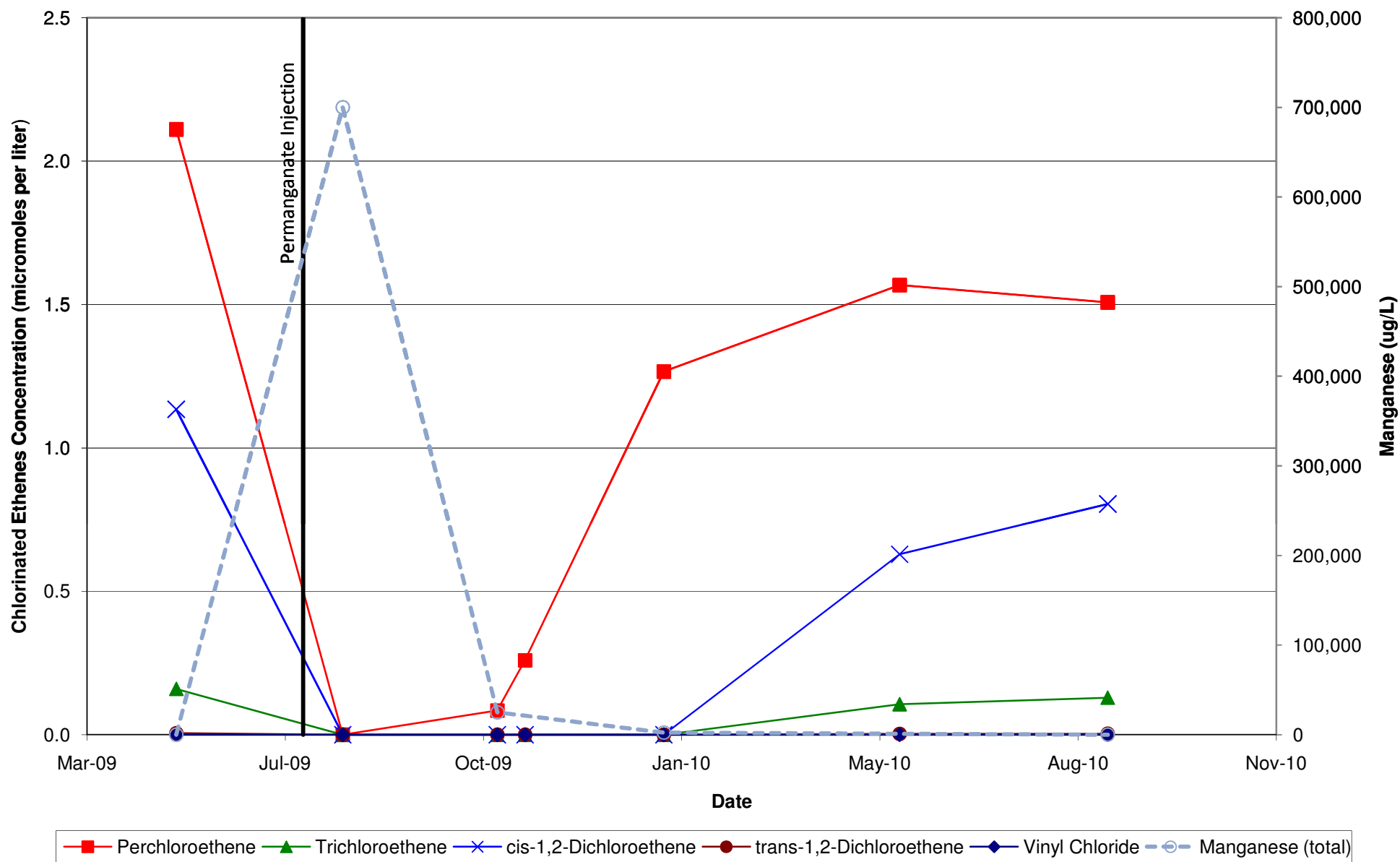


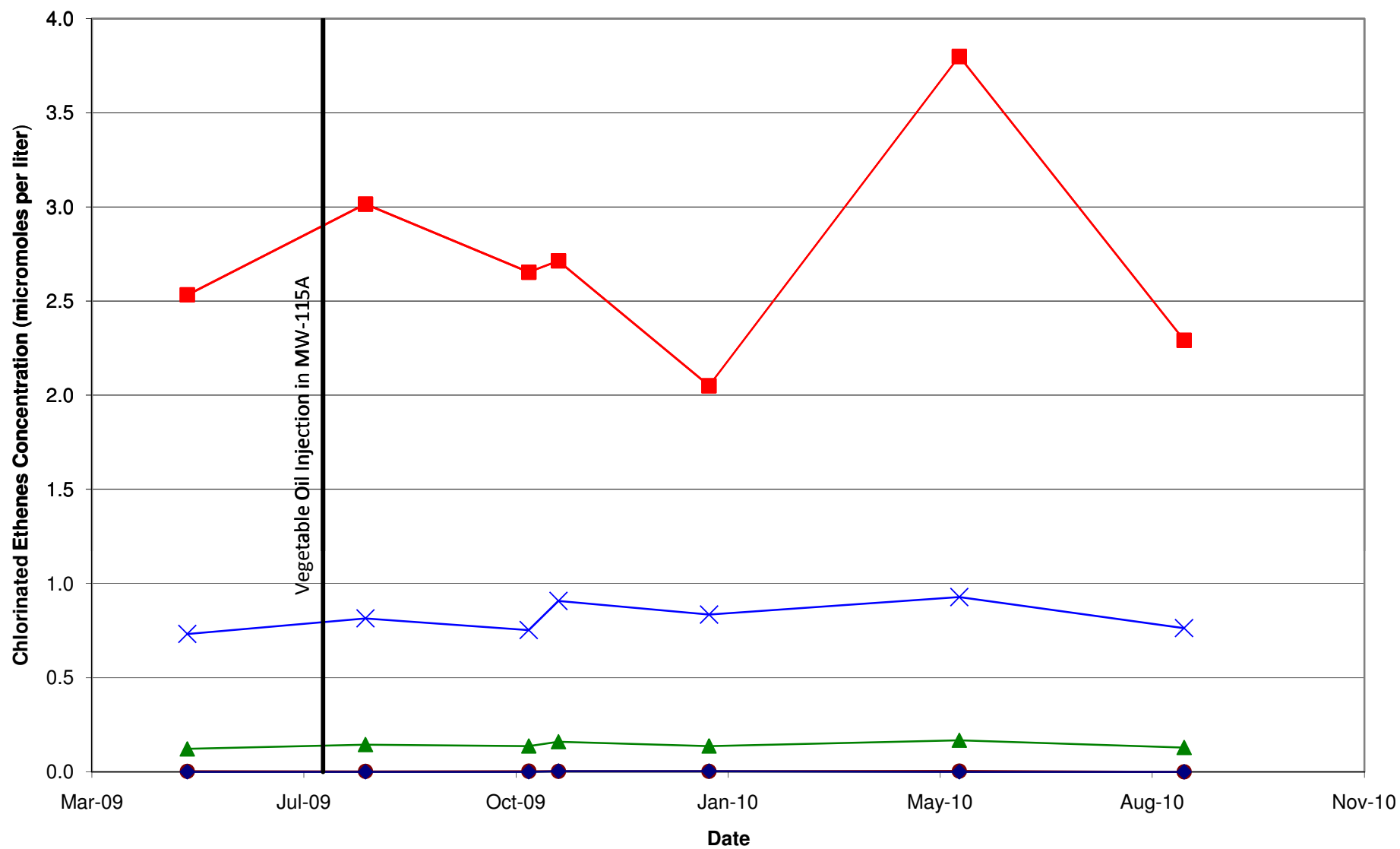


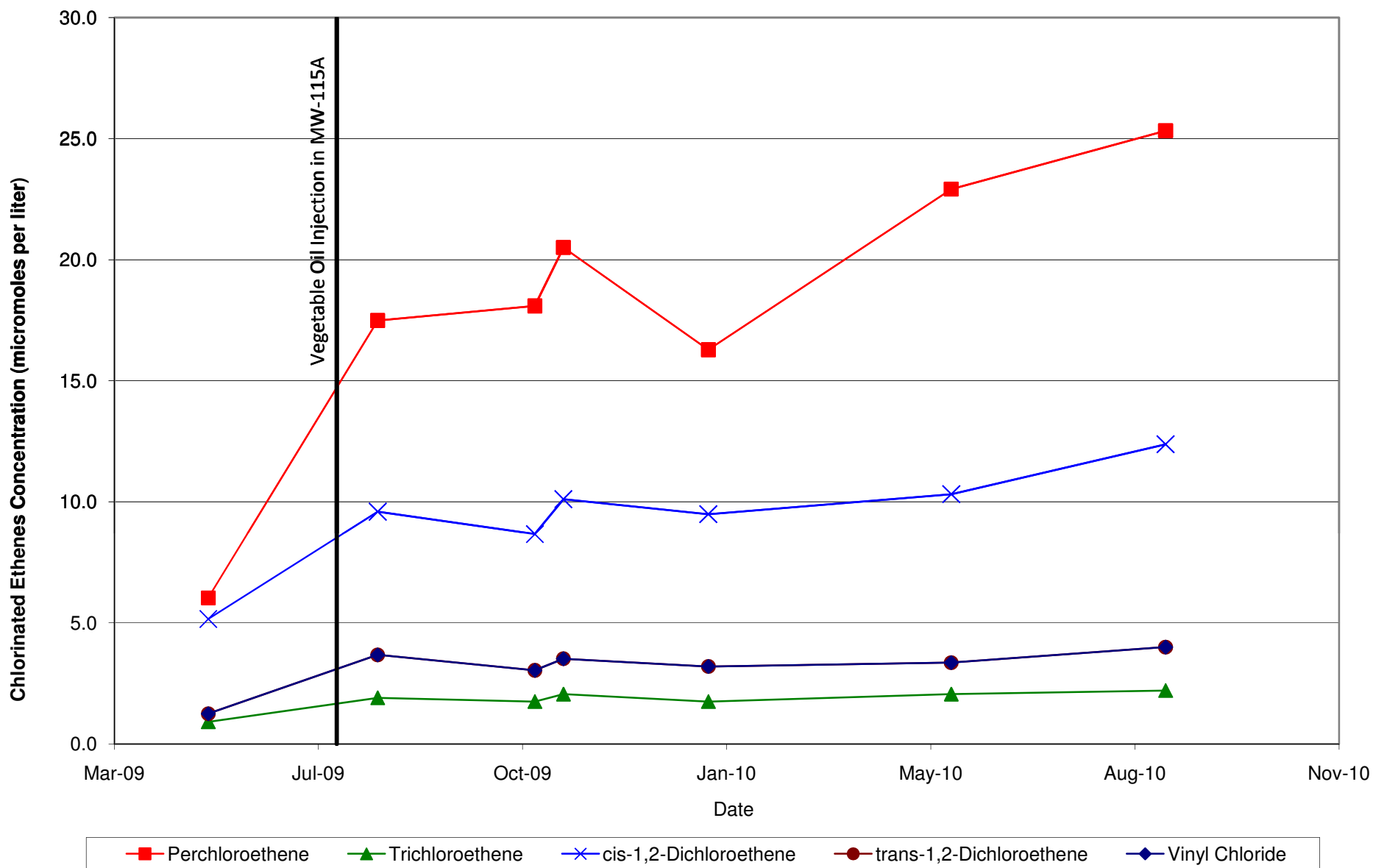


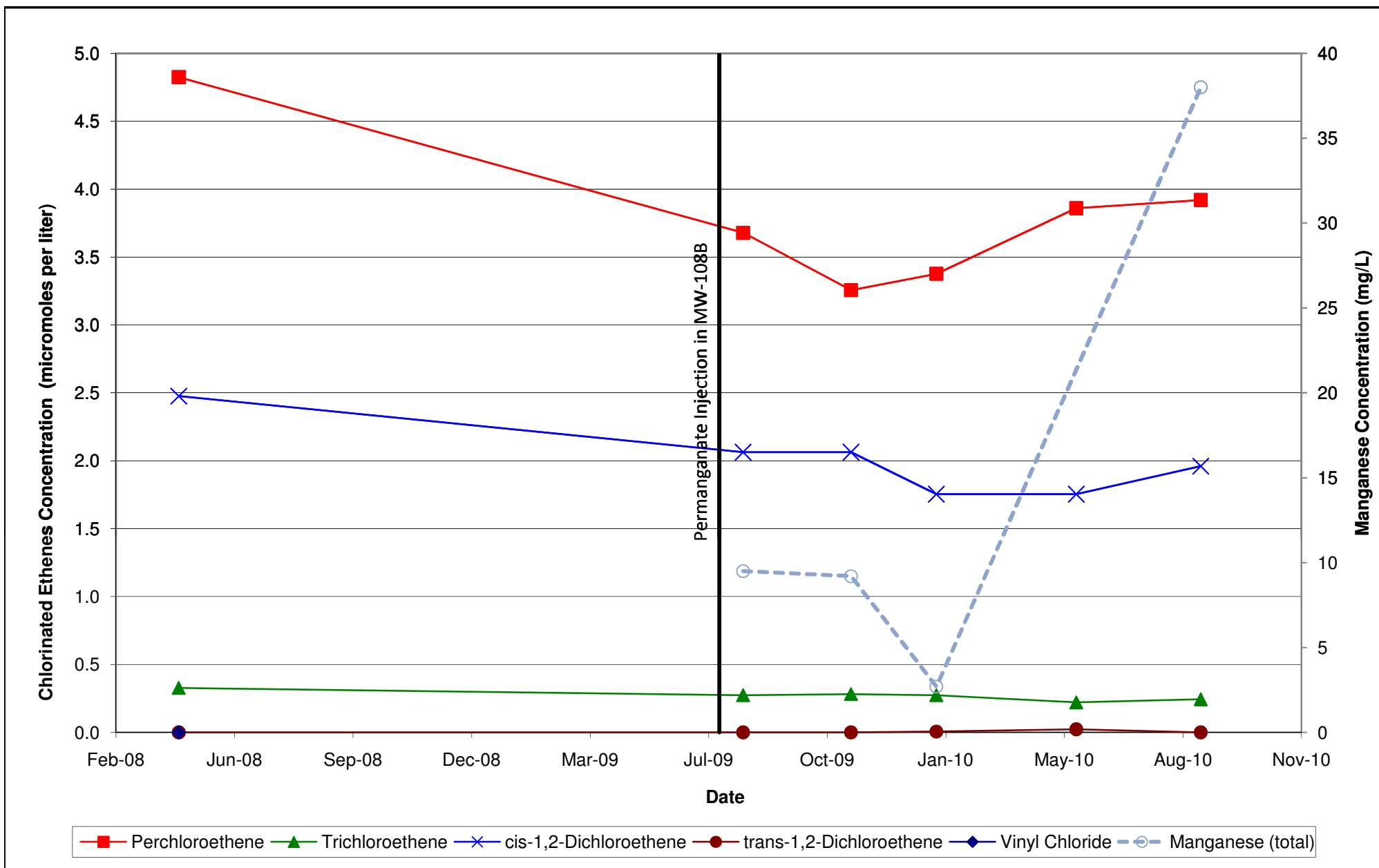












APPENDIX A

HOT SPOT PILOT TEST FIELD ACTIVITIES SUMMARY

FOR

CHEMPLEX SITE IN CLINTON, IOWA

Prepared For

ACC/GCC

Project No. 1006907.0103

October 2009

Prepared by

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SECTION 1.0 – INTRODUCTION

This report documents field activities completed in July 2009 at the Chemplex Site in Clinton, Iowa as part of the implementation of the Hot Spot Pilot Work Plan (Work Plan) dated March 2009. Solutions of vegetable oil or permanganate were injected in designated monitoring wells and former extraction wells. This report will present the injection volumes, recommendations for future injection activities, and recommendations regarding further monitoring of the current injection activities. Results will be reported and evaluated in two separate reports, to be completed following the completion of six and twelve months of monitoring.

1.1 SITE BACKGROUND

The Chemplex Site encompasses approximately 630 acres in Clinton County, Iowa in Sections 19, 20, 29, and 30, Township 81 North, Range 6 East. The site lies approximately 1.5 miles northwest of the city of Camanche and 5.5 miles west of the city of Clinton on U.S. Highway 30. The site includes the former Chemplex facility, now operated by Equistar Chemicals LP (Equistar), and surrounding farm land (Figure 1). The land which the plant now occupies was formerly used for agriculture, and much of the surrounding land is still used for this purpose.

The polyethylene production facility began making low-density polyethylene (LDPE) and high-density polyethylene (HDPE) in 1968. This process is carried out by first producing ethylene from liquefied petroleum gas and then mixing it with catalysts to produce solid polyethylene beads (LDPE) and flakes (HDPE). These products are then shipped in trucks and railroad cars. A major byproduct of the polyethylene manufacturing process is debutanized aromatic concentrate (DAC), a liquid at normal temperature and pressure, which is approximately 40 to 50 percent benzene. This byproduct is stored in aboveground tanks inside the plant and is eventually sold and shipped via railroad car or tanker truck.

The West Region of the site includes a 7-acre landfill that was used for the disposal of various materials, including demolition debris and water treatment sludges. From about 1968 to 1978 perchlorethene (PCE or tetrachloroethene) was used from time to time to clean clogged piping (ENSR Consulting and Engineering [ENSR], 1990). Spent PCE was disposed within the landfill in accordance with typical PCE disposal practices at the time.

The Chemplex landfill is the primary source of PCE to groundwater. A second, unidentified source is believed to exist within the East Region of the polyethylene plant. The landfill contains PCE, as well as DAC and oils; however, the East Region source contains PCE but not DAC. The second source, which could not be identified during the Remedial Investigation, is believed to be smaller than the landfill source (Montgomery Watson, 1992).

PCE in the form of dense nonaqueous phase liquid (DNAPL) is believed to have traveled through the overburden and migrated horizontally and vertically in bedrock until such time as it became immobile, due to being absorbed into surrounding rock pores (sorption) or after being

trapped in dead-end fractures that permeate the Scotch Grove Formation (the uppermost bedrock layer at the site). Residual DNAPL may have remained along the travel routes within the soil overburden and the fractures of the Scotch Grove Formation. The top of the Scotch Grove Formation is approximately 5 to 50 feet below ground surface. The entire formation (Upper Scotch Grove and Lower Scotch Grove) is approximately 100 feet thick. Impacts are also detected in the Picture Rock, Farmers Creek, Lower Hopkinton, and Blanding layers underlying the Scotch Grove formation.

PCE that has been sorbed into rock pores is believed to be back-diffusing into groundwater, and migrating through bedrock via groundwater transport. It is expected that matrix diffusion will serve as a long-term, ongoing source of PCE to groundwater.

1.2 PURPOSE

The purpose of the Hot Spot field activities was to collect data to assess the viability of in-situ treatment technology to address localized “hot spots” of elevated PCE concentrations that have been identified or may arise in the future. Assessment of hot spot treatment is one component of the revised remedy identified as Alternative 3 – Exposure Control in the Final Focused Feasibility Study (FFS) (Erler & Kalinowski, Inc. [EKI], 2007).

1.3 PRE-INJECTION AUTHORIZATION

The Work Plan presented the evaluation of candidate injection solutions, considerations, and a post-injection monitoring plan. The Work Plan was reviewed by the United States Environmental Protection Agency (USEPA). Prior to injection activities, the USEPA Underground Injection Control office and the Iowa Department of Natural Resources (IDNR) reviewed the Work Plan and indicated, via electronic mail, that injection permits would not be required. Copies of this correspondence are provided in Appendix A.

1.4 INJECTION OVERVIEW

Over the course of three weeks, permanganate or vegetable oil was injected into a total of six monitoring and former extraction wells. During the course of the pilot test, certain injection procedures were modified, including injection techniques and dilution factors for vegetable oil, due to observed field conditions. Representatives of the USEPA were on site for the injection of permanganate and the start of vegetable oil injection activities.

Select photographs of injection equipment and activities are provided in Appendix B. Figure 2 is a site map showing the locations of the wells into which the injections were completed.

1.5 BASELINE SAMPLING

Prior to injections, a site-wide groundwater sampling event was conducted in May 2009. The proposed injection points and select monitoring wells were sampled for volatile organic compounds (VOCs) and natural attenuation analytes. These data will be used in evaluation of post-injection groundwater data. The sample results for the injection points and selected downgradient monitoring points are summarized in Table 1.

SECTION 2.0 – VEGETABLE OIL INJECTION

Vegetable oil was injected at five locations to provide electron donor to promote biological growth. The emulsified vegetable oil product was purchased from Terra Systems, Inc. (Terra Systems) of Wilmington, Delaware. Based on groundwater sampling and permeability testing conducted prior to the injections, 11,175 pounds of 60 percent emulsified vegetable oil was delivered to the Chemplex Site. The vegetable oil was stored in the Chemplex Treatment Building until needed.

Injection log sheets are provided in Appendix C. Recorded data during the injections included time, injection volume, wellhead pressure, and notes. The data were used to estimate injection rates, injection volumes, and aquifer conditions.

2.1 VEGETABLE OIL PRODUCT

The product purchased from Terra Systems is marketed as Slow Release Substrate (SRS™). The product is available with a 1-micron mean droplet size and a 5-micron mean droplet size. The 5-micron droplet size (SRS-FR™) is marketed for fractured rock applications such as those at the Chemplex Site, with the assumption that the larger droplet size is more likely to be retained on the fracture surfaces, whereas the small droplet size is more likely to move advectively.

Although the injection points are known to be screened in fractured rock, it is believed that much of the current biological activity, evidenced by the detection of PCE's biological degradation daughter products, is occurring in micro-environments. To accommodate both the fractures and micro-environments, the applied vegetable oil product was an equal part mixture of SRS™ and SRS-FR™. The concentrated vegetable oil also contained approximately 4 percent sodium lactate to serve as readily-available substrate for the microbes. The vegetable oil product shipped to the site was a food-grade material.

Based on the groundwater data presented in Table 1, and permeability testing, Terra Systems estimated the required injection volume for each well. For the five vegetable oil injection points, the target total injection volume was 11,175 gallons of concentrated vegetable oil product.

2.2 INJECTION HARDWARE AND GENERAL SET-UP

Each injection point was handled separately and no simultaneous injections from the same batch of vegetable oil were completed. Polyethylene tanks were used to store pumped groundwater used for mixing and chase water. Groundwater was used to help match the injected solution to in-situ conditions. Additional polyethylene tanks were used as mix tanks for the vegetable oil and water. Two small centrifugal pumps ($\frac{1}{2}$ and $\frac{3}{4}$ horse power [hp]) or a Grundfos® groundwater pump were used to pump the mixed vegetable oil into the wells. Various set-ups were used at the wellheads including shallow-placed packers, deep-placed packers, drop tubes, and combinations of drop tubes and packers. Pressure gauges were in line at the flow totalizer and/or the injection wellhead. The set-up used at each wellhead is

noted in the subsequent sections. The pumps were powered by portable gasoline-powered generators or by electrical service available at former extraction wells. Piping between tanks, pumps, and the wellhead were made with pressure and vacuum-rated tubing. Piping connections were made with cam-style fittings.

Two injection points, MW-115A and MW-116A, are located inside the fenced perimeter of the Equistar facility. Equipment and work clearances were obtained from Equistar prior to injection activities at these points. No more than the equivalent of one full tote of concentrated vegetable oil was on Equistar property at any time.

2.3 INJECTION POINT MW-115A

2.3.1 Injection Preparation

Monitoring well MW-115A is a 2-inch diameter well with a total depth of 120 feet. In preparation for injection, approximately 2,100 gallons of water were purged using existing polyethylene tubing and a Hydrolift® electric actuator. Purge water was used for dilution of the vegetable oil emulsion, as well as chase water, following injection. Purge volume was calculated based on a target ratio of 3 gallons of water to 1 gallon of the 60 percent vegetable oil emulsion product. The planned injection volume was 447 gallons of concentrated vegetable oil product at a 17 percent dilution based on modeling completed by the vegetable oil vendor, Terra Systems.

2.3.2 Injection Narrative

The injection at MW-115A commenced on July 16, 2009, using one injection pump. An inflatable packer was set approximately 15 feet below the top of casing (TOC) to facilitate injection under moderate pressure. The 60 percent concentrated vegetable oil was diluted to approximately 17 percent (a 2.5:1 mixture with purge water). Initial flow rates were between 10 and 20 gallons per minute (gpm). After approximately six hours of injection, the flow rate had decreased to less than 1 gpm. Due to the declining flow rate, two pumps were used in series, increasing the injection pressure and resulting in an increased flow rate. Approximately 850 gallons of diluted vegetable oil solution were injected at MW-115A on the first day of injection.

On July 17, 2009, an additional batch of dilute vegetable oil was prepared and the injection resumed. Using the same two-pump injection set up as the previous day yielded an average flow rate of approximately 0.25 gpm. This flow rate was too low for practical application and it appeared the assimilative capacity of the well had been reached at roughly two-thirds of the targeted injection volume. The liquid level in the well was observed to decrease, indicating that although the pressurized injection was resulting in a low flow rate, the formation was accepting some volume of injection fluid and was not entirely blocked. Approximately 13 gallons of chase water were injected over 2 hours and 20 minutes to clean out the pumps and tubing on July 17, 2009. A siphon was established from the dilute vegetable oil tank to the well and left in place overnight on July 17, 2009 to allow the tank to keep the well casing filled with injection fluid above the native ground water elevation but without overflowing the well casing. Although the siphon did move a small volume of vegetable oil solution, the siphon broke at some point during

the night after about 25 gallons were injected via this siphon system. The siphon was reestablished, allowing an additional 10 gallons to be applied.

Pressurized injection activities resumed on July 21, 2009. The packer was set at the same location, but a drop tube of polyethylene tubing was attached to the bottom of the packer and extended to the screen. In an effort to clear oil-laden fluid from the well casing, the initial injection was chase water applied using two pumps in series. After approximately 36 gallons of chase water were injected over 2 hours and 25 minutes, another attempt was made to inject diluted vegetable oil. Approximately 30 gallons of vegetable oil were injected during three hours of pressurized injection. A siphon set up was again attempted without moving noticeable volumes of liquid. At this point, the injection effort at this well was suspended.

In total, approximately 287 gallons of concentrated (60 percent) vegetable oil and 53 gallons of chase water were injected into MW-115A.

The remaining diluted vegetable oil was relocated for injection into well MW-116A (after additional dilution) and, later, into EW-3a. These injections are discussed in greater detail in subsequent sections. The remaining well purge water was transported to the DAC-B lift station inside the Equistar facility and pumped to the Chemplex Treatment Building for treatment and discharge.

2.4 INJECTION POINT MW-116A

2.4.1 Injection Preparation

Monitoring well MW-116A is a 2-inch diameter well with a total depth of 118 feet. Monitoring well MW-116A is located in the Equistar facility, west of MW-115A. An inflatable packer was placed approximately 15 feet below the TOC and a polyethylene drop tube extended from the packer to the well screen. In preparation for injection, approximately 2,450 gallons of water were purged from MW-116A using existing polyethylene tubing and a Hydrolift® electric actuator. Purge water was to be used for dilution of the vegetable oil emulsion, as well as chase water, following injection. Based on the experiences at injection point MW-115A, the purge water volume was increased to allow a target dilution of 10 percent vegetable oil and still have sufficient chase water volume to clean the well casing. The 10 percent target dilution rate was suggested by Terra Systems as a means to reduce the viscosity of the diluted solution and possibly increase the volume of the injection.

2.4.2 Injection Narrative

The injection at MW-116A was started using diluted vegetable oil that was not injected into MW-115A. This vegetable oil solution was further diluted with potable water from the Chemplex Treatment Building, which in turn is derived from the Equistar deep production wells. This potable water was used instead of shallow groundwater because the VOC concentration from MW-115A was significantly higher than that at MW-116A, and using VOC-free potable water for dilution helped reduce VOC levels in the MW-116A injection water to concentrations more representative of MW-116A. Initially, the vegetable oil solution was diluted approximately two

parts water to one part solution. After two small batches were injected the ratio was changed to three parts water for subsequent batches.

The injection at MW-116A proceeded using two pumps plumbed in series. A maximum flow rate of 4.7 gpm was achieved during the first batch, with both pumps engaged. After injecting slightly more than 150 gallons of dilute solution, the flow rate dropped to less than 0.5 gpm. This indicated that MW-116A was behaving like MW-115A and that the continued injection of vegetable oil product would be limited; therefore, the injection of vegetable oil was stopped when the last batch of diluted vegetable oil was injected. Approximately 28 gallons of chase water were then injected at MW-116A, at an injection rate of approximately 0.4 gpm.

The purge water from MW-116A was not used for dilution of vegetable oil. The purge water was transported to the DAC-B lift station inside the Equistar facility and pumped to the Chemplex Treatment Building for treatment and discharge.

In total, approximately 8 gallons of concentrated (60-percent) vegetable oil and 28 gallons of chase water were injected into well MW-116A.

2.5 INJECTION POINT EW-7b

2.5.1 Injection Preparation

Former extraction well EW-7b is an 8-inch diameter well with a total depth of 163 feet. The pitless adapter fitted into the side of the casing pipe was plugged prior to the injection. In preparation for injection, approximately 1,550 gallons of water were purged using a Grundfos® submersible pump. Purge water was to be used for dilution of the vegetable oil emulsion, as well as chase water, following injection. The planned injection volume was 250 gallons of concentrated vegetable oil product at a 17 percent dilution.

Two different packers were used during the injection activities at EW-7b. The well inside diameter is actually 8 $\frac{3}{8}$ inches and the initial well seal would not properly seat in the well casing. As an alternative, an inflatable, wheel-style packer was placed approximately 1 foot below the TOC for much of the injection process. A 1 $\frac{1}{2}$ -inch diameter pipe extended through the center of the wheel, which enabled a seal against the casing, while maintaining a flow pathway for the injection. The wheel-style packer was used for injection pressures up to 20 pounds per square inch (psi).

For some follow-up activities, as noted below, an inflatable packer was placed in the well at a depth slightly above the well screen. When the inflatable packer was used, a pump rig was on site to assist in setting and retrieving the packer. Flexible hose was used between the top of the packer and the injection pump.

2.5.2 Injection Narrative

Pressurized injection activities at EW-7b on July 17, 2009 were executed using the wheel style packer and a Grundfos® submersible pump. Water was poured on top of the packer to facilitate

early detection if the seal was compromised. A Grundfos® pump was inserted into the mix tank and the effluent stream directed to the packer.

The first injection batch was approximately 100 gallons of concentrated vegetable oil diluted to 250 gallons for a 17 percent vegetable oil solution. During injection of the first batch, the injection rate was an average of 5.3 gpm, with pressure not exceeding 15 psi. Injection of batch one was completed in just over an hour.

After this successful first injection, the volume for the second injection run at EW-7b was increased to 525 gallons at the same dilution. Initial flow rates were consistent with batch one, fluctuating above 5 gpm; however, after just under an hour the wellhead pressure increased sharply. To stabilize wellhead pressure, the flow rate was decreased to approximately 1 gpm. As the pressure continued to rise, the injection flow rate was further decreased. After roughly 3 hours, the flow rate was too low to detect with the totalizer.

Injections continued until there were approximately 45 gallons of diluted vegetable oil left in the mix tank. The remaining 45 gallons were transferred into 5-gallon buckets for transport to EW-14b. Once the mix tank was nearly empty, it was mobilized for injection at EW-14b.

Additional vegetable oil injection and chase water injection was attempted using gravity feed over an extended time period; however, this proved ineffective. There was approximately 4 feet of height differential between the natural water level in EW-7b and the TOC, resulting in a 4-foot water column when the space was filled, or about 1.7 psi of additional pressure at the well screen.

An attempt was then made to reduce the amount of residual oil solution within the water column of EW-7b. Since the shallow packer was placed near the TOC, the entire water column contained the diluted vegetable oil. On July 30, 2009, water that had been planned for use as chase water was pumped into EW-7b through a drop tube that rested on the bottom of the well. This water injection caused the water column to rise. The displaced vegetable oil mix was collected and pumped to a polyethylene tank in a pick-up truck.

A traditional inflatable packer was then lowered into well EW-7b and placed approximately 5 feet above the well screen. The contents of the tank, which had been removed from the well casing, were then injected through the packer. Over the course of 12.5 hours, approximately 385 gallons of dilute vegetable oil were injected at a pressure of approximately 40 psi. Over the course of the injection, the flow rate decreased from about 0.8 gpm to less than 0.3 gpm. Approximately 24 gallons of remaining purge water were then injected as chase water.

In total, approximately 217 gallons of concentrated (60 percent) vegetable oil and 24 gallons of chase water were injected into well EW-7b.

2.6 INJECTION POINT EW-14b

2.6.1 Injection Preparation

Former extraction well EW-14b is an 8-inch diameter well with a total depth of 173 feet. The pitless adapter was plugged prior to the injection. In preparation for injection, approximately 1,300 gallons of water were purged from this well using a Grundfos® submersible pump. Purge water was intended to be used for dilution of the vegetable oil emulsion, as well as chase water, following injection. The planned injection volume was 274 gallons of concentrated vegetable oil product at a 17 percent dilution.

2.6.2 Injection Narrative

An initial phase of injection into the well was completed using the material removed in buckets from EW-7b on July 22, 2009. A ¾-inch diameter polyvinyl chloride (PVC) drop tube was installed to the bottom of the well and connected to a polyethylene tank into which the contents of the buckets were placed. Approximately 33 gallons of dilute vegetable oil were added to the well using this gravity-feed method. Based on experience at MW-115A, MW-116A, and EW-7b, an inflatable packer for the 8-inch well was procured prior to continuing with the injection on July 28, 2009.

An inflatable packer was installed in EW-14b using a pump rig. The packer was set about 5 feet above the well screen and connected to a flow totalizer and pumps by flexible tubing. Based on experiences at other wells, the batches of dilute vegetable oil were kept small and more dilute than prior injections. Approximately 20 gallons of concentrated vegetable oil were added to 120 gallons of water for an injection solution of about 9 percent vegetable oil. A total of seven batches were made with this volume and dilution. After this successful series of injections, the determination was made to increase the concentration to 17 percent. For two batches the volume was maintained at 140 gallons and the last batch was 189 gallons at the same dilution. Vegetable oil was readily injected in EW-14b. With only the ¾-hp pump in operation, injection pressures were about 37 psi and flow rates were consistently above 4 gpm. By the end of the injection, the injection pressure was still about 37 psi and the injection rate had decreased to about 2 gpm.

Figure 3 shows the injection flow rate at EW-14b as a function of total volume of diluted vegetable oil injected. The flow rate generally decreased over time with each successive batch. For the last three batches injected into EW-14b, which were at approximately a 17 percent vegetable oil concentration, the injection rate appears to have decreased more rapidly than for the previous seven batches.

Chase water was injected into EW-14b at end of injection activities on July 28, 2009 and again after all injection activities at the well were completed on July 29, 2009. A total of approximately 200 gallons of chase water was injected. Following the completion of vegetable oil injections, the chase water flow rate was approximately 3.5 gpm, which was higher than the final vegetable oil injection rate of approximately 2 gpm.

In total, approximately 273 gallons of concentrated (60 percent) vegetable oil and 400 gallons of chase water were injected into well EW-14b.

2.7 INJECTION POINT EW-3a

2.7.1 Injection Preparation

Well EW-3a is an 8-inch diameter former extraction well with a total depth of 98 feet located north of the Chemplex Treatment Building. The well was not originally planned to be an injection point; but was identified as a suitable location for injecting remaining oil solutions in a Chemplex Site area where elevated PCE concentrations had been noted in the past. The historic concentrations of PCE in EW-3a exceeded the concentrations in all the other injection points, such that PCE in the injected solution that resulted from dilution with purge water would not be of concern.

2.7.2 Injection Narrative

The injection at EW-3a commenced on July 29, 2009. An 8-inch packer was set just above the top of screen to facilitate injection under pressure. Initial flow rates were between 8 and 9 gpm, using the diluted vegetable oil remaining from MW-115A.

On July 30, 2009 the remaining injection activities at EW-3a were completed. The injection was completed under pressure using the packer set above the top of screen. The remaining concentrated vegetable oil was mixed with potable water from the Chemplex Treatment Building and injected into EW-3a. Potable water was used for dilution because it was readily available and VOC free, thus if the injection could not proceed to completion, the remaining solution would not contain PCE. The potable water was also used to rinse tanks and totes containing the concentrated vegetable oil. The rinsate was injected into EW-3a. The EW-3a injections proceeded smoothly with injection rates consistently above 7.5 gpm.

Flow rates typically ranged from 7.5 to 8.5 gpm with two pumps in series. There was a steady decline in flow rate during vegetable oil injection; however, this decline was smaller compared with that seen in the other injection wells. When switching from vegetable oil to chase water, the flow rate increased rapidly.

In total, approximately 585 gallons of concentrated (60 percent) vegetable and 399 gallons of chase water were injected into well EW-3a.

SECTION 3.0 – PERMANGANATE INJECTION

3.1 PERMANGANATE PRODUCT

Permanganate was used as an injection solution to oxidize PCE and other VOCs. Sodium permanganate, which is a liquid, was purchased from Carus Chemical Company Inc. (Carus) in LaSalle, Illinois. Carus markets the selected product as REMOX[®]L. Based on groundwater sampling and permeability testing conducted prior to the injections, 89 gallons of 40 percent permanganate solution were ordered and delivered to the Chemplex Site in two 55-gallon plastic drums. The permanganate was stored in the Chemplex Treatment Building until needed.

An injection log sheet is provided in Appendix C. Recorded data during the injection included time, totalizer volume, wellhead pressure, and notes. The data were used to estimate injection rates, injection volumes, and aquifer conditions.

3.2 INJECTION PREPARATION

Monitoring well MW-108B, located on Equistar property outside the main fenced portion of the facility, was the permanganate injection point. Prior to injection activities, approximately 520 gallons of water were pumped from MW-108B and placed in two pick-up truck polyethylene tanks. Approximately 100 gallons were injected back into MW-108B in the process of testing pump, piping, and packer connections. An inflatable packer was placed approximately 15 feet below the TOC in MW-108B for the injection. All permanganate mixing was completed at the Chemplex Treatment Building.

3.3 INJECTION NARRATIVE

The MW-108B injection was conducted on July 15, 2009. The concentrated permanganate product was added to approximately 250 gallons of purge water for a permanganate concentration of approximately 10 percent. The water was contained in a pick-up truck tank and the permanganate was pumped from the two drums. No additional mixing of the tank contents was conducted.

The diluted permanganate was transported to MW-108B. The tank outlet was connected to the 3/4-hp pump and wellhead. The injection proceeded rapidly with a ball valve adjusted to allow variation of wellhead pressures. Due to the corrosive nature of the permanganate, no flow totalizer was used; however, volumes were estimated based on tank readings. Over the course of 24 minutes, approximately 340 gallons of permanganate solution were injected. Wellhead pressures ranged from 29 to 36 psi and no significant difficulties were noted.

Both the truck tank containing the dilute injection solution and the remaining purge water were transported back to the Chemplex Treatment Building. Approximately 120 gallons of water were used to rinse the two permanganate drums. The rinse water was placed in the dilute solution tank, transported to MW-108B, and injected. Following the rinse water, approximately 150 gallons of chase water were injected into the well.

SECTION 4.0 – INJECTION SUMMARY

4.1 VEGETABLE OIL

Vegetable oil injection during the Hot Spot pilot study is summarized in Table 2. Injection point EW-14b more readily accepted the vegetable oil injection than EW-7b, although both wells are screened within the same Farmers Creek unit. The use of an inflatable, down-hole packer may have also increased the effectiveness of several injections. Well EW-3a, which readily accepted vegetable oil, is screened in the highly weathered Upper Scotch Grove unit and has a relatively longer, 30-foot screen. The other vegetable oil injection points are screened within less weathered bedrock layers and have a 10-foot screen.

When pumping ceased at MW-115A and EW-7b, the wellhead pressure quickly dissipated. At MW-116A, however, residual pressure did not dissipate as quickly; indicating flow pathways were likely more limited than at MW-115A or EW-7b.

Injection flow rates varied between wells and throughout the injection at each well. The higher initial rates of injection observed at MW-115A, MW-116A, and EW-7b likely represent water being pushed from the well and filter pack to the formation. When the vegetable oil reached the formation or possibly the filter pack, the flow rate may have slowed significantly due to the increased viscosity of the vegetable oil solution relative to groundwater.

A decrease in flow rate was also evident at EW-14b; however, the flow rate did not drop off as significantly as at the aforementioned wells. At EW-14b, the largest portion of the injected vegetable oil was in a 9 percent solution. As shown in Figure 3, the injection rate at EW-14b did continue to decrease over the course of the injection and this rate of decrease accelerated when a 17 percent vegetable oil solution was injected. This further suggests that viscosity had an important role in limiting the injection capacity.

The largest-volume vegetable oil injections were in former extraction wells with large boreholes and well casings. A larger borehole diameter could promote distribution of the vegetable oil product. For example, a 10-foot screen in a nominal 6-inch diameter boring (such as at MW-115A and MW-116A) has a surface area contact of 15.7 square feet with the formation, whereas a 10-foot screen in a nominal 14 3/4-inch borehole (such as at EW-7b and EW-14b) has approximately 38.6 square feet of contact with the formation. The larger surface area increases the possible points of distribution into the formation.

All vegetable oil product delivered to the Chemplex Site was injected into the subsurface. The target injection volume was achieved at EW-14b. The EW-7b and MW-115A injection volumes were more than 50 percent of the target volume; however, planned chase water injections were not fully completed.

Several factors likely combined to control the feasible vegetable oil injection volume, including solution viscosity, available fracture flow pathways and fracture apertures, and contact area with the formation. Higher pressure pumps may have been able to temporarily mitigate the viscosity

effects, although it is expected that even using higher injection pressures would not have materially delayed the observed decreased in injection flow rate. The completed injection at EW-14b suggests a more highly-diluted mixture may be more appropriate for fractured bedrock conditions at the Chemplex Site; however, other factors such as the local fracture network, including fracture average apertures and interconnectedness, may also have affected relative injection performance.

4.2 PERMANGANATE

The permanganate pilot study well, MW-108B, readily accepted the injection solution and did not demonstrate a significant loss of flow rate or increase in injection pressure. This ready acceptance may have been facilitated by the relatively low viscosity of the permanganate injection solution compared with vegetable oil.

SECTION 5.0 – RECOMMENDATIONS FOR FUTURE INJECTION ACTIVITIES

Groundwater monitoring results will be used to evaluate the injections and develop recommendations regarding future applications for hot spot treatment. Pending evaluation of future groundwater monitoring results, several initial recommendations can be made regarding procedures for future injections.

5.1 DILUTION WATER AND BATCH SIZE

For mixing vegetable oil, if the ability of the well to accept the injection has not been previously demonstrated, potable water should be considered for dilution instead of well purge water to control VOC levels in the injection fluid, allowing use of the fluid at any candidate injection location. The diluted solution should also be made in small batches until it can be determined that larger volumes will be accepted by the well and surrounding formation. For the pilot study, it was considered desirable to use the groundwater extracted from the injection points to maintain constant water chemistry in the injection fluid, potentially reducing the variables when evaluating the data.

The dilution ratio should be kept high to reduce the vegetable oil concentration and thus lower the viscosity of the injection solution. The injections during the pilot study started at approximately 17 percent vegetable oil, but increased in flow rate at less than 9 percent vegetable oil.

5.2 USE INFLATABLE PACKERS TO FACILITATE PRESSURIZED INJECTION

The use of an inflatable packer likely increased the effectiveness of the injections. Any future injection should be planned with a packer being placed a short distance above the well screen. Advantages of this method include higher pressure injections, smaller well casing volume to displace, and a less-oily post-injection water column. Due to the weight of the packers and depth of the screened intervals, a pump rig or other mechanical means of support should be used to help set the packers. For 2-inch wells, it may be difficult to deploy the packer to the target depth due to small clearances and possible loose or off-set well casing joints.

5.3 SODIUM VERSUS POTASSIUM PERMANGANATE

Due to the apparent flow-limiting effects of solution viscosity, it is recommended that any future permanganate injections continue to use sodium permanganate rather than the solid potassium permanganate. Although the solid form will dissolve in water, it could leave undissolved residuals or be incompletely mixed; leaving particles that could reduce the aquifer permeability.

5.4 USE OF DEDICATED INJECTION WELLS

The Work Plan calls for monitoring of the hot spot results in the injection locations and selected downgradient locations. If feasible, based on the existing well pattern, the well that triggered the need for treatment may not be the best injection point, as its suitability as a monitoring point would be limited by the injection.

SECTION 6.0 – RECOMMENDATIONS FOR GROUNDWATER MONITORING

Following the field activities for implementation of the Work Plan, the sampling protocols should be modified in part. There is vegetable oil remaining in the water columns of MW-115A and EW-7b, such that these wells were not sampled as part of the August 2009 one-month post injection sampling event. EW-14b, at which the targeted injection proceeded as planned, also displayed vegetable oil in the purge water when sampled in August. When residual oil is present, traditional monitoring equipment for pH, conductivity, and oxidation-reduction potential (ORP) cannot be used because oil can ruin the membranes on these instruments.

The VOC analytical data must also be considered individually. The VOCs present in groundwater could preferentially partition to the oil fraction, resulting in an artificially high VOC concentration if residual oil is collected in the sample.

6.1 LIMITED SAMPLING OF MW-115A AND EW-7B

Due to the residual vegetable oil in MW-115A and EW-7b, samples were not collected from these wells during the August 2009 sampling event. Samples from these wells would not be useful in evaluating the pilot study at this time. An additional attempt to sample these wells will be made at least once during the first year of post-injection monitoring. Given the reportedly long life of the vegetable oil, concentrations of vegetable oil in the well water columns may take some time to dissipate. For well MW-115A, downgradient well MW-129A, which is in the sampling plan, will help assess the injection effectiveness. There is no similar downgradient well for EW-7b.

6.2 SAMPLING MW-112A

While on site for the permanganate injection at MW-108B, USEPA personnel asked about the sampling status of MW-112A, which is located downgradient of MW-108B. At the request of the USEPA, this additional well was sampled during the August 2009 sampling event. Monitoring well MW-112A will continue to be sampled for VOCs as part of the hot spot sampling events for three more events (approximately 3, 6, and 12 months following the injection). There are no baseline pilot test data from MW-112A, but there are historic VOC concentrations available.

SECTION 7.0 – REFERENCES

ENSR. May 1990. *Investigation Report for Phase 1 Remedial Design, Field Investigation*. ENSR Consulting and Engineering.

Erler & Kalinowski, Inc. 2007. *Final Focused Feasibility Study (Volumes I, II, and III). Operable Unit No. 1 for Groundwater*. Chemplex Site. Clinton, Iowa.

Montgomery Watson. August 1992. *First Operable Unit Remedial Investigation Report*.

MWH March 2009. *Hot Spot Pilot Test Work Plan*. Chemplex Site, Clinton, Iowa.

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TABLES

TABLE 1
SUMMARY OF BASELINE GROUNDWATER DATA
CHEMPLEX SITE
HOT SPOT PILOT STUDY

Parameter		MW-108B	MW-109B	MW-115A	MW-116A
Injection Solution		Permanganate	None	Vegetable Oil	Vegetable Oil
Tetrachloroethene	µg/L	340/350	420	3,600	870
Trichloroethene	µg/L	21/20	16	340	71
trans-1,2-Dichloroethene	µg/L	0.52/0.47	0.3 J	6.4	1.5
cis-1,2-Dichloroethene	µg/L	110/100	71	1,300	300
Vinyl chloride	µg/L	<0.50/<0.50	<0.50	250	15
Alkalinity, Total	mg/L	260/260	240	280	250
Alkalinity, Bicarbonate	mg/L	260/260	240	280	250
Alkalinity, Carbonate	mg/L	<10/<10	<10	<10	<10
Alkalinity, Hydroxide	mg/L	<10/<10	<10	<10	<10
Ammonia	mg/L	<0.05/<0.05	<0.05	<0.05	<0.05
Chloride	mg/L	28/28	7.0	58	22
Ethane	µg/L	<11/<11	6.9 J	52	9.6 J
Ethene	µg/L	<9.9/<9.9	7 J	23	7.7 J
Iron (II) (Dissolved)	µg/L	<50/<50	<50	<50	<50
Iron (Total)	µg/L	42 J/<50	<50	NR	1,000
Manganese (II) (Dissolved)	µg/L	<10/<10	<10	2 J	12
Manganese (Total)	µg/L	2 J/<10	1 J	NR	33
Methane	µg/L	3 J/3.5 J	6.3	120	11
Nitrate-Nitrogen	mg/L	22/22	18	9.0	11
Nitrite-Nitrogen	mg/L	<1.0/<1.0	<0.10	<1.0	<1.0
Sulfate	mg/L	40/40	31	72	52
Sulfide	mg/L	<0.50/<0.50	<1.0	<0.50	<0.50
Total Organic Carbon	mg/L	0.74 J/0.76 J	<1	6.1	1.2
ORP	milivolts	-1	120	138	-4
pH	pH units	7.06	7.53	7.19	7.16
Dissolved Oxygen	mg/L	2.00	6.51	0.00	0.00

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

J = Reported value is between method detection limit and reporting limit.

ORP = Oxidation-reduction potential.

NR = Not reported.

Actual volumes are based on flow totalizer readings.

TABLE 1
SUMMARY OF BASELINE GROUNDWATER DATA
CHEMPLEX SITE
HOT SPOT PILOT STUDY

Parameter		MW-129A	EW-7b	EW-14b
Injection Solution		None	Vegetable Oil	Vegetable Oil
Tetrachloroethene	µg/L	1,000	270	990
Trichloroethene	µg/L	120	17	99
trans-1,2-Dichloroethene	µg/L	2.8	<0.50	2.0
cis-1,2-Dichloroethene	µg/L	500	12	310
Vinyl chloride	µg/L	78	<0.50	36
Alkalinity, Total		300	270	260
Alkalinity, Bicarbonate		300	270	260
Alkalinity, Carbonate		<10	<10	<10
Alkalinity, Hydroxide		<10	<10	<10
Ammonia		<0.05	<0.05	0.065
Chloride		28	2.3	16
Ethane	µg/L	13	7.7 J	24
Ethene	µg/L	8.8 J	7.5 J	13
Iron (II) (Dissolved)	µg/L	<50	<50	<50
Iron (Total)	µg/L	NR	53	63
Manganese (II) (Dissolved)	µg/L	14	1.6 J	65
Manganese (Total)	µg/L	NR	2 J	57
Methane	µg/L	13	6.2	83
Nitrate-Nitrogen	mg/L	11	4.2	8.3
Nitrite-Nitrogen	mg/L	0.71 J	<0.10	<1.0
Sulfate	mg/L	58	14	27
Sulfide	mg/L	<0.50	<1.0	<1.0
Total Organic Carbon	mg/L	2.1	0.65 J	1.4
ORP	millivolts	178	99	93
pH	pH units	7.22	7.56	7.55
Dissolved Oxygen	mg/L	0.00	0.67	0.20

Notes:

µg/L = Micrograms per liter.

mg/L = Milligrams per liter.

J = Reported value is between method detection limit and reporting limit.

ORP = Oxidation-reduction potential.

NR = Not reported.

Actual volumes are based on flow totalizer readings.

TABLE 2

**SUMMARY OF VEGETABLE OIL INJECTIONS
CHEMPLEX SITE
HOT SPOT PILOT STUDY**

Injection Point	Concentrated Vegetable Oil (60 percent)					Chase Water		Notes
	<u>Target Injection</u>		<u>Actual Injection</u>		<u>Percent of Target</u>	<u>Target</u>	<u>Actual</u>	
	(gal)	(lbs)	(gal)	(lbs)		(gal)	(gal)	
MW-115A	447	3619	287	2,322	64%	1,050	53	Difficulty injecting after first pore volume.
MW-116A	409	3309	8	69	2.1%	1,000	28	Difficulty injecting.
EW-7b	250	2021	217	1,756	87%	600	24	Difficulty injecting after first pore volume.
EW-14b	274	2223	273	2,202	99%	700	400	Accepted material readily.
EW-3a	-	-	585	4,726	-	-	399	Accepted material readily.

Notes:

gal = Gallons.

lbs = Pounds.

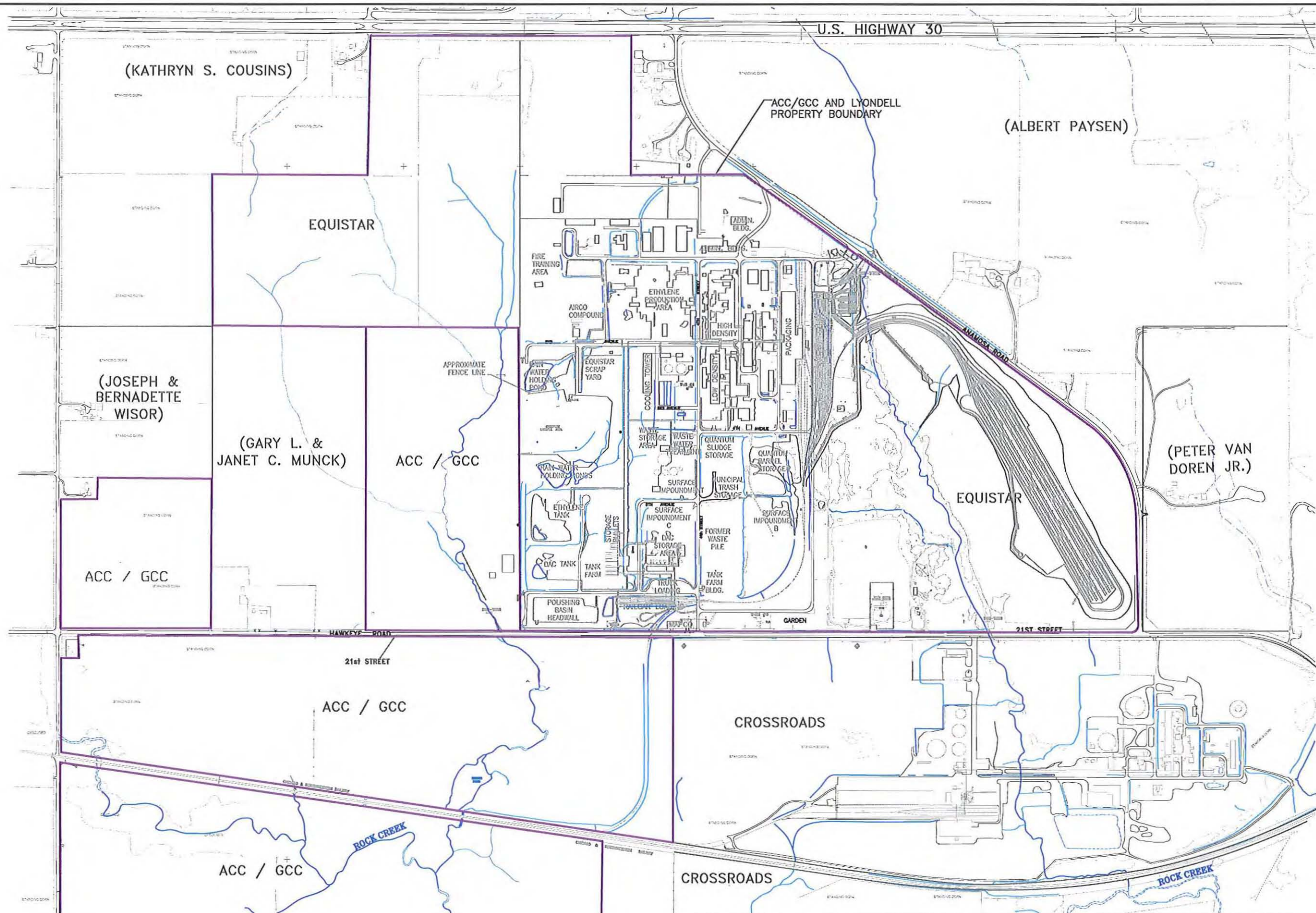
Actual volumes are based on flow totalizer readings.

FIGURES

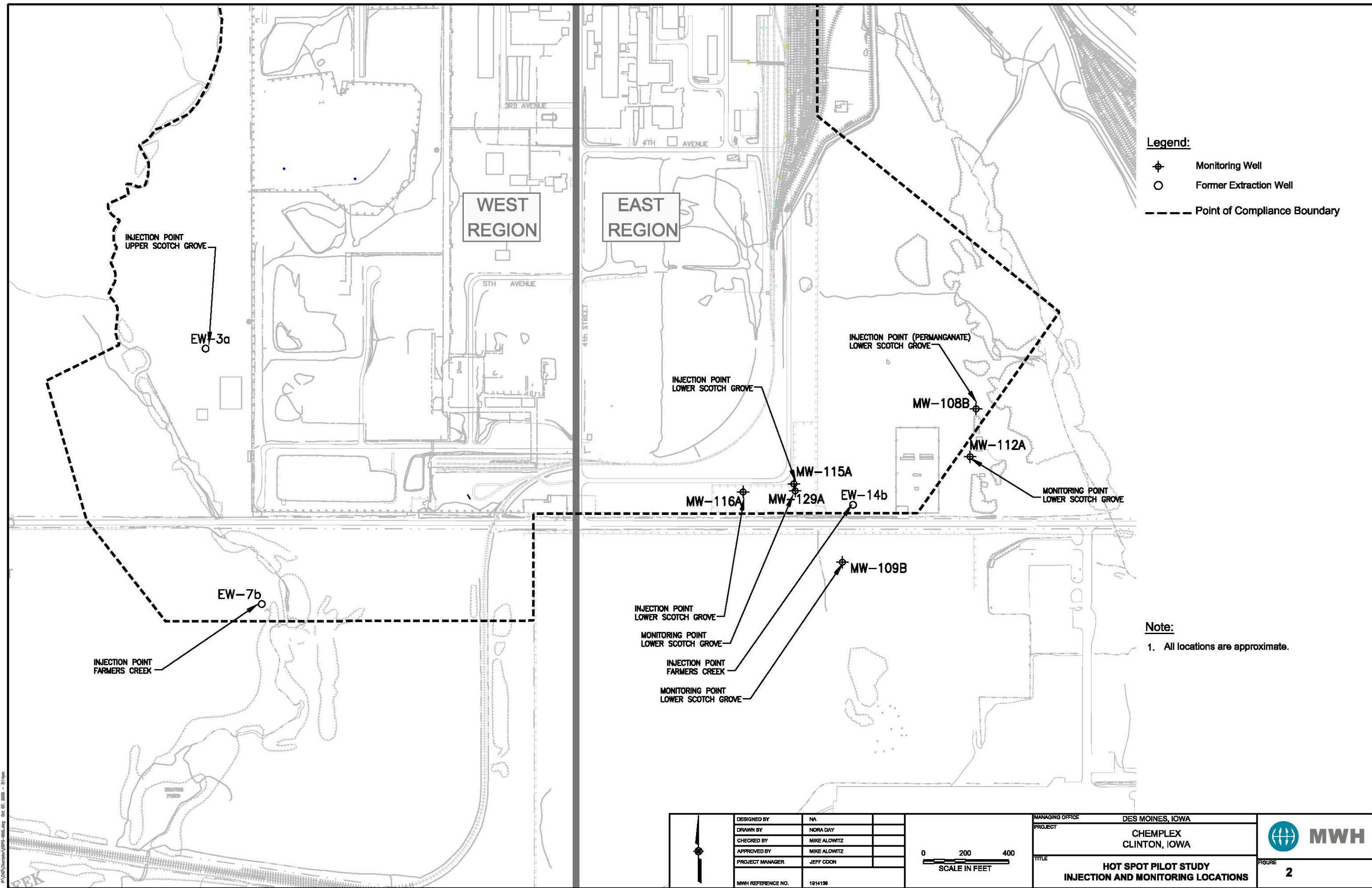


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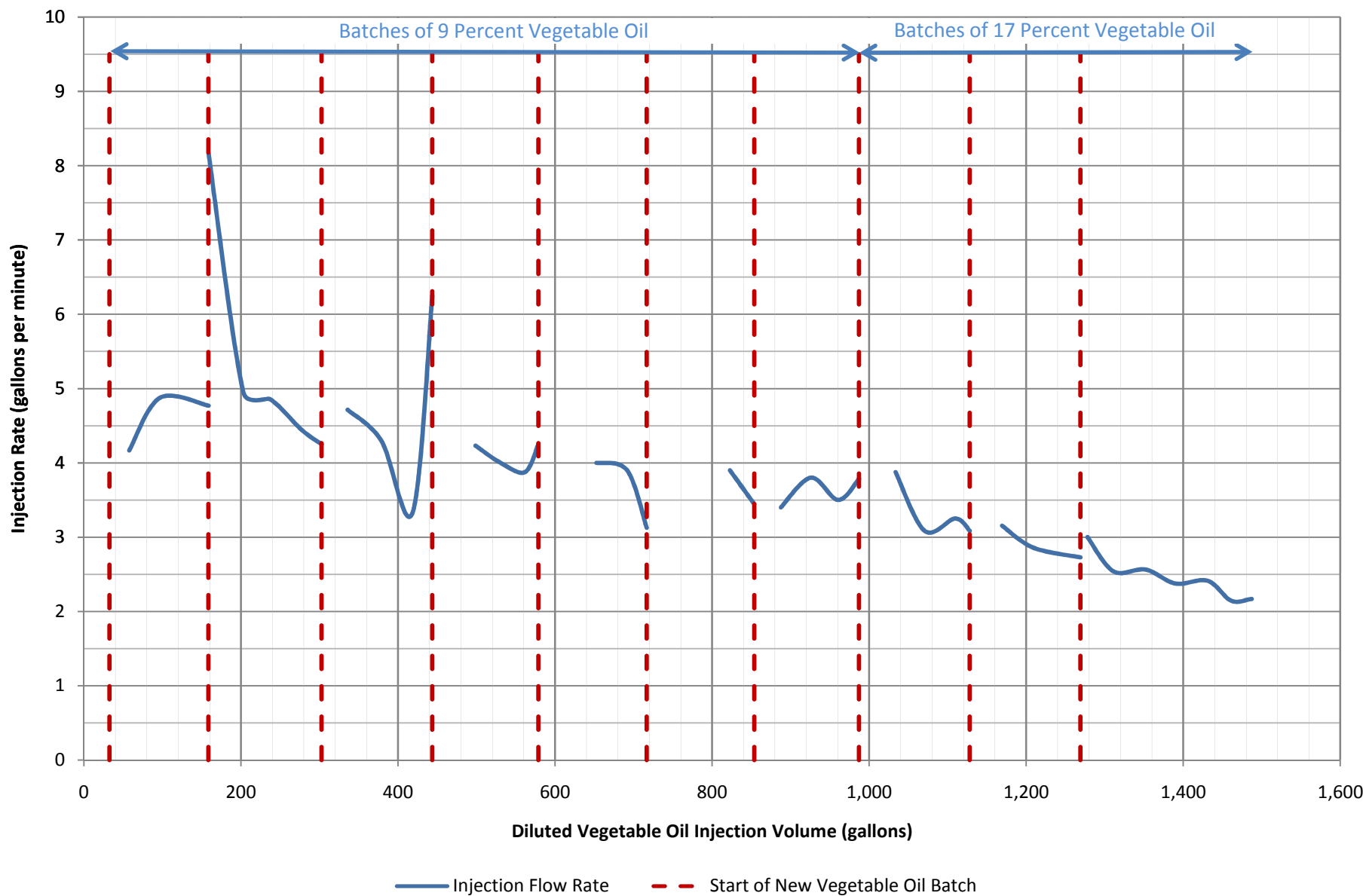



 0 5000 10000 SCALE IN FEET	DESIGNED BY	NA	PROJECT LOCATION PROJECT CHEMPLEX CLINTON, IOWA TITLE SITE MAP AND PROPERTY OWNERS	 MWH FIGURE 1
	DRAWN BY	NORA DAY		
	CHECKED BY	MIKE ALLOWITZ		
	APPROVED BY	MIKE ALLOWITZ		
	PROJECT MANAGER	JEFF COON		
	MWH REFERENCE NO.	1914135.0101		



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	DESIGNED BY	NA	 SCALE IN FEET	MANAGING OFFICE	DES MOINES, IOWA	
	DRAWN BY	NORA DAY		PROJECT	CHEMPLEX CLINTON, IOWA	
	CHECKED BY	MIKE ALOWITZ		TITLE	HOT SPOT PILOT STUDY INJECTION AND MONITORING LOCATIONS	
	APPROVED BY	MIKE ALOWITZ				
	PROJECT MANAGER	JEFF COON				
	MWH REFERENCE NO.	1014136				FIGURE 2



PROJECT LOCATION	DES MOINES		
PROJECT	CHEMPLEX HOTSPOT PILOT TEST		
TITLE	EW-14B VEGETABLE OIL INJECTION RATE AS A FUNCTION OF VOLUME INJECTED		
FIGURE	3	REVISION	1
FILE NAME			

APPENDIX A

Michael Alowitz

From: Hildebrandt.Kurt@epamail.epa.gov
Sent: Friday, June 26, 2009 10:00 AM
To: Michael Alowitz
Cc: Mindrup.Mary@epamail.epa.gov; Swyers.Nancy@epamail.epa.gov;
michael.anderson@dnr.iowa.gov; calvin.lundberg@dnr.iowa.gov
Subject: Proposed In-Situ Remediation/Chemical Oxidation Injection Pilot - Chemplex Superfund Site (Clinton, Iowa)

Categories: Chemplex

Michael Alowitz, P.E.
Senior Environmental Engineer
MWH
11153 Aurora Avenue
Des Moines, Iowa 50322

Dear Mr. Alowitz:

We have reviewed the information that you have provided regarding MWH's proposed use of vegetable oil and sodium permanganate for the remediation of groundwater contaminated by PCE and its breakdown products at the Chemplex Superfund Site located at 3400 Anamosa Road in Clinton, Iowa. The emplacement of the materials into the subsurface that has been proposed in your remediation plan is regulated by the Underground Injection Control (UIC) Program as a Class V injection well.

Injection wells in this classification are allowed to operate either as Rule Authorized, or under conditions of a permit. The decision to permit these operations is based on the following criteria: whether the injectate could cause a violation of the Primary Drinking Water Regulations under 40 CFR § 124 or otherwise adversely affect the health of humans; the duration of the project; frequency of injection; and the volume of fluids to be injected. Additionally, while injection well operations at Superfund related sites do not require permitting by the UIC program, they do require review and approval by the UIC program before they can begin operation. To ensure the protection of underground sources of drinking water, the Region typically requires permits to be obtained for all non-Superfund related aquifer remediation injection wells by the authorities granted the Administrator under 40 CFR § 144.25(a)(3).

Based on the information that has been provided, the pilot injection/emplacement of vegetable oil and sodium permanganate to encourage in-situ remediation at the site should not result in an adverse impact to any underground sources of drinking water or otherwise adversely affect the health of humans. Therefore, it has been determined that the five wells which you are proposing to use in the pilot to emplace approximately 18,000 pounds of remediation materials will be allowed to operate as Rule Authorized under 40 CFR § 144.24 without the need for permitting and have been assigned a EPA UIC facility ID number of IAS045260001. Please note that the EPA Region 7 UIC program will need to be made aware of any subsequent injection at this site or similar projects in Iowa before commencing operation so that a determination can be made if rule authorization is appropriate.

While a UIC permit will not be required, the EPA Region 7 UIC program will need to be made aware of the final volume of fluids that were injected by the five injection wells. By the authorities granted under 40 CFR § 144.27, we are also requesting that the results of all groundwater monitoring and copies of any reports and notifications required by either the Superfund program or the Iowa Department of Natural Resources (IDNR) be submitted as the pilot project progresses to the Director at the following address:

U.S. Environmental Protection Agency - Region 7
Attention: Kurt F. Hildebrandt
Drinking Water and Groundwater
Management Branch (WWPD/DRWM)
901 North 5th Street
Kansas City, Kansas 66101

All correspondence should reference the UIC facility ID number, site name, address, and any additional EPA or IDNR registration numbers. The authorization by rule automatically terminates for any failure to comply with the above requirements.

While the EPA Region 7 UIC program has approved this injection activity, this does not preclude the need to obtain approval from the State of Iowa. In Iowa, the Water Quality Bureau of IDNR handles the state approval of injection activities. Therefore, the proposed injection activity MAY NOT commence until you have received approval from IDNR.

Please contact me if you should have any questions on this decision and its requirements or any other UIC related issues.

Sincerely,
Kurt Hildebrandt

US-EPA Region 7
901 North 5th Street
Kansas City, KS 66101

Phone: 913-551-7413
Fax: 913-551-9413

Michael Alowitz

From: Anderson, Michael [DNR] [Michael.Anderson@dnr.iowa.gov]
Sent: Monday, July 06, 2009 8:28 AM
To: 'Hildebrandt.Kurt@epamail.epa.gov'; Michael Alowitz
Cc: Mindrup.Mary@epamail.epa.gov; Swyers.Nancy@epamail.epa.gov;
calvin.lundberg@dnr.iowa.gov
Subject: RE: Proposed In-Situ Remediation/Chemical Oxidation Injection Pilot - Chemplex Superfund Site (Clinton, Iowa)

Categories: Chemplex

We have examined the information that MWH provided on behalf of Chemplex and have determined that no water allocation permit is needed for this application. We have no objections to the use of vegetable oil and NaMnO₃ for groundwater remediation at this site.,.

-----Original Message-----

From: Hildebrandt.Kurt@epamail.epa.gov [mailto:Hildebrandt.Kurt@epamail.epa.gov]
Sent: June 26, 2009 10:00 AM
To: Michael Alowitz
Cc: Mindrup.Mary@epamail.epa.gov; Swyers.Nancy@epamail.epa.gov; Anderson, Michael [DNR];
calvin.lundberg@dnr.iowa.gov
Subject: Proposed In-Situ Remediation/Chemical Oxidation Injection Pilot - Chemplex Superfund Site (Clinton, Iowa)

Michael Alowitz, P.E.
Senior Environmental Engineer
MWH
11153 Aurora Avenue
Des Moines, Iowa 50322

Dear Mr. Alowitz:

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Based on the information that has been provided, the pilot injection/emplacement of vegetable oil and sodium permanganate to encourage in-situ remediation at the site should not result in an adverse impact to any underground sources of drinking water or otherwise adversely affect the health of humans. Therefore, it has been determined that the five wells which you are proposing to use in the pilot to emplace approximately 18,000 pounds of remediation materials will be allowed to operate as Rule Authorized under 40 CFR § 144.24 without the need for permitting and have been assigned a EPA UIC facility ID number of IAS045260001. Please note that the EPA Region 7 UIC program will need to be made aware of any subsequent injection at this site or similar projects in Iowa before commencing operation so that a determination can be made if rule authorization is appropriate.

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Attention: Kurt F. Hildebrandt
Drinking Water and Groundwater
Management Branch (WWPD/DRWM)
901 North 5th Street
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Please contact me if you should have any questions on this decision and its requirements or any other UIC related issues.

Sincerely,
Kurt Hildebrandt

US-EPA Region 7
901 North 5th Street
Kansas City, KS 66101

Phone: 913-551-7413
Fax: 913-551-9413

APPENDIX B



Photograph 1: Transferring concentrated permanganate solution from drums to groundwater in a poly tank in the pick-up truck. The concentrated permanganate was stored at the treatment building and was not transported to the wellhead.
Date: 07/15/2009



Photograph 2: Injection of permanganate solution at MW-108B. The diluted permanganate solution was pumped through an inflatable packer.
Date: 07/15/2009



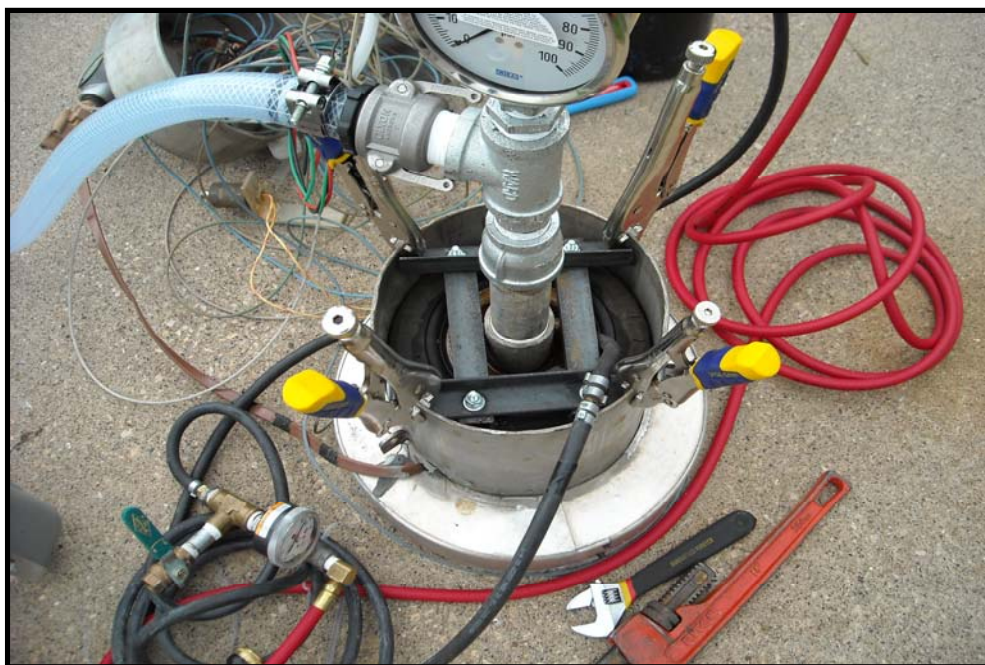
MWH

**CHEMPLEX HOT SPOT
INJECTION SUMMARY REPORT**



Photograph 3: Mixing of vegetable oil as it is pumped into the bottom of a tank containing groundwater.

Date: 07/17/2009



Photograph 4: The inflatable wheel-style packer initially used at EW-7b. The wellhead piping was similar for other connections, including a pressure gauge and cam-lock fittings.

Date: 07/17/2009



MWH

**CHEMPLEX HOT SPOT
INJECTION SUMMARY REPORT**



Photograph 5: Transfer of excess diluted vegetable oil from a truck tank inside the LyondellBasell facility to a tank near the Chemplex treatment building.

Date: 07/23/2009



Photograph 6: Chemical totes in which the vegetable oil was shipped. The tote on the ground was used for mixing vegetable oil with potable water.

Date: 07/30/2009



MWH

**CHEMPLEX HOT SPOT
INJECTION SUMMARY REPORT**



Photograph 7: The set-up at EW-7b to try and clean out the water column. Purge water was pumped through a drop tube to the bottom of the well. The rising vegetable oil and water mix
Date: 07/30/2009 drained to the bucket and was pumped to tank.



Photograph 8: The packer used to seal the former injection wells. Vegetable oil was pumped through the green hose. The clear plastic tubing was an inflation line for the packer. The packer in
Date: 07/30/2009 this picture had just been removed from EW-3a.



MWH

**CHEMPLEX HOT SPOT
INJECTION SUMMARY REPORT**

APPENDIX C

FIELD INJECTION REFERENCE SHEET

WELL: EW-3a

Date/Time at start of injection: 7/29/2009

Weather conditions at start of injection: _____

Injection Fluid: Vegetable Oil

Injection personnel: Tim Wineland, Jen Hiatt, Mike Alowitz

Injection Pump: 3/4 HP

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/29/09 16:45	34	59342	--	0	Start (veg oil from MW-115A) DTW ~.6 ft, ~8.8 GPM,
7/29/09 16:58	34	59452	8.46	110.0	Stopped @ 59485.5 weep pipe filling well vault
7/29/09 18:03	33	59485.5	--	143.5	Restarted injection after capping weep pipe ~9GPM
7/29/09 18:19	33	59624	8.66	282.0	~8.8 GPM
--	--	59729	--	387.0	Finished injection of MW-115A Mix (~400 Gals)
7/30/09 7:30	35	59729.5	--	387.5	Start injection of pure veg oil w/potable water
7/30/09 7:37	35	59770	5.79	428.0	9 GPM
7/30/09 7:43	--	59812	7	470.0	stopped @~7:43, need to find new weep pipe cap
7/30/09 8:26	35	59812	--	470.0	Restart pumping veg oil mix ~8.8 gpm
7/30/09 8:35	35	59887	8.33	545.0	8.8 GPM
7/30/09 8:44	35	59964	8.56	622.0	8.5 GPM
7/30/09 9:00	34	59997	2.06	655.0	8.3 GPM
7/30/09 9:54	35	59997	--	655.0	8.4 GPM
7/30/09 10:09	35	60301	--	959.0	7.8 GPM
7/30/09 10:28	34	60446	7.63	1104.0	7.7 GPM
7/30/09 10:56	34	60600	5.5	1258.0	7.8 GPM
7/30/09 11:08	34	60692	7.67	1350.0	7.8 GPM
7/30/09 11:23	33	60810	7.87	1468.0	7.5 GPM
7/30/09 11:35	33	60902	7.67	1560.0	7.4 GPM
7/30/09 11:44	--	60963	6.78	1621.0	Stop Veg Oil Injection
7/30/09 11:47	34	60963	--		8.4 GPM, start potable water injection
7/30/09 12:07	34	61120	7.85		8.1 GPM
7/30/09 12:17	--	61185	6.5		Stop water injection
7/30/09 14:02	34	61314	2.87	1621.0	8.6 GPM start veg oil sludge injection
7/30/09 14:13	--	61417.5	9.41	1724.5	Stop Sludge injection
7/30/09 14:19	--	61455	--	1762.0	Mix tank sludge injection 8.1 GPM
7/30/09 14:24	--	61491.5	7.30	1798.5	Stop injection
7/30/09 14:28	34	61547	--	1854.0	Mix tank sludge injection
7/30/09 14:35	--	61604	8.14	1911.0	Stop injection
7/30/09 14:37	35	61604	--		Start chase water injection 8.5 GPM
7/30/09 14:59	--	61781	8.05		Stop chase water injection

NOTES:

FIELD INJECTION REFERENCE SHEET

WELL: EW-7b

Date/Time at start of injection: 7/17/2009

Weather conditions at start of injection: ~60°F, W at 5-10 mph, clear

Injection Fluid: Vegetable Oil

Injection personnel: Tim Wineland, Jen Hiatt, Mike Alowitz

Injection Pump: Grundfos Rediflo 2

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/17/09 8:37	--	58073	--	0	Start - 210 Hz, ~4 GPM (100 gal veg oil/ 250 gal H ₂ O)
7/17/09 8:40	8	58085	4.00	12	Bump to 301 Hz, ~5.7 GPM, 3.1 A
7/17/09 8:43	13	58101	5.33	28	
7/17/09 8:50	14	58140	5.57	67	301 Hz, 4.0 Amps, Tank at ~280 gal
7/17/09 9:00	14	58185	4.50	112	
7/17/09 9:10	14	58248	6.30	175	301 Hz, 4.0 Amps, Flow at 5.5 GPM, Tank at ~170 gal
7/17/09 9:20	14	58301	5.30	228	
7/17/09 9:23	--	--	--	228	Removed Pump from Tank Riser and place on side
7/17/09 9:30	13	58339	--	266	
7/17/09 9:40	14	58393	5.40	320	5.4 GPM, nearly empty
7/17/09 9:43	--	58412	6.33	339	Pump drawing air, stop to remix
7/17/09 9:45	--	58413.5	0.75	340.5	flushed pump in 5 gal bucket of well water
7/17/09 11:33	--	58414	--	341	Start 2nd Batch (150 gal veg oil/ 375 gal H ₂ O)
7/17/09 11:42	14	58465	5.67	392	~5.5 GPM, 300.1 Hz
7/17/09 11:53	14	58522	5.18	449	
7/17/09 12:26	17	58698	5.33	625	~2 GPM, Tank at ~200 gal, 174.5 Hz, 3.1 A
7/17/09 12:37	18.5	58710	1.09	637	Pressure Increasing, settings 167.9 Hz, 3.0 A
7/17/09 12:47	17.5	58724	1.40	651	Pressure Increasing, 155.08 Hz, 2.9 A, ~ 1 GPM
7/17/09 13:17	19	58749	0.83	676	Removed Pump from Tank Riser and place on side
7/17/09 13:20	--	58749	0.00	676	~.4 GPM
7/17/09 13:56	19-20	58765	0.44	692	
7/17/09 14:33	20	58770	0.14	697	
7/17/09 15:08	20	58770	0.00	697	Totalizer Malfunctioning
7/21/09	--	--	--	--	H ₂ O Gravity Feed, no totalizer
7/21/09 11:22	--	--	--	--	Begin feeding H ₂ O (150 gals)
7/21/09 12:30	--	--	--	--	~150 Gals fed, ~150 GPH
7/21/09 12:55	--	--	--	--	Gravity Feed refilled ~175 Gal, 400 Remaining in tank
7/21/09 15:15	--	--	--	--	Gravity Feed refilled ~200 Gal
7/21/09 16:30	--	--	--	--	Feed mostly empty (~50 Gal) refilling
7/22/09 6:20	--	--	--	--	~600 gal in tank, refilled small tank, rain got into tank*

NOTES:

Morning 7/17 - Have 250 gals H₂O in mix tank - want to add 100 gal of veg oil

55356 to start @06:44, 55455 - 99 Gallons

* Siphon discovered between the gravity feed tank and the poly tank, nothing was injected via gravity feed.

On 7/30/2009, pushed "clear" water (previously pumped in) into EW-7b via

drop tube & collected @ surface in attempt to clean up water column

Goal was to clean up well casing, but want to try to inject the material removed

from casing so as to try to push out more vegetable oil

FIELD INJECTION REFERENCE SHEET

WELL: EW-7b

Date/Time at start of injection: 7/30/2009 Reinjection with Packer

Weather conditions at start of injection: Sunny

Injection Fluid: Vegetable Oil

Injection personnel: Tim Wineland, Jen Hiatt, Mike Alowitz

Injection Pump: 3/4 HP & 1/2 HP in series

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/30/09 16:04	40	61781	--	0	Installed packer above screen, 1GPM instantaneous
7/30/09 16:33	40	61804	0.79	23	0.9 GPM
7/30/09 16:57	40	61824	0.83	43	0.9 GPM
7/30/09 17:16	40	61840	0.84	59	0.85 GPM
7/30/09 17:43	40	61862.5	0.83	82	0.8 GPM
7/30/09 18:04	40	61879	0.79	98	0.75 GPM
7/30/09 18:23	40	61892	0.68	111	0.7 GPM
7/30/09 18:40	40	61903	0.65	122	0.65 GPM
7/30/09 19:06	40	61921	0.69	140	0.6 GPM
7/30/09 19:44	40	61942.8	0.57	162	0.6 GPM
7/30/09 20:30	40	61968.5	0.56	188	0.6 GPM instantaneous
7/30/09 21:00	40	61983.2	0.49	202	0.4 GPM
7/30/09 21:31	39.5	61994.8	0.37	214	0.1+ GPM - Will Recheck in a bit
7/30/09 21:41	39.5	61996.2	0.14	215	No known reason for drop in rate
7/30/09 21:47	40	61997.2	0.17	216	0.6 GPM sm pump not running, plugged back in
7/30/09 22:00	40	62004	0.52	223	0.6 GPM
7/30/09 22:30	40	62020.5	0.55	240	0.5+ GPM, estimate 165 gal left in tank
7/30/09 23:00	40	62036.2	0.52	255	0.5 GPM instantaneous
7/30/09 23:30	40	62051	0.49	270	0.5 GPM
7/31/09 0:00	40	62065.4	0.48	284	Shut off pumps for night, ~120 gals left
7/31/09 5:49	40	62065.9	--	285	Restart pumps - tank at ~120
7/31/09 6:24	40	62085	0.55	304	~0.5 GPM instantaneous
7/31/09 7:00	40	62103.2	0.51	322	~80 gallons in tank
7/31/09 7:30	40	62118	0.49	337	~0.5 GPM
7/31/09 8:00	40	62128.4	0.35	347	~0.4 GPM
7/31/09 8:30	40	62135.9	0.25	355	Tank @ ~50 gallons
7/31/09 9:07	40	62144.1	0.22	363	
7/31/09 9:30	40	62150.9	0.30	370	
7/31/09 10:01	40	62159.4	0.27	378	~25 gallons left, tank tipped so rough estimate
7/31/09 10:31	40	62167.5	0.27	387	Stopped veg oil
7/31/09 10:34	40	62167.8	0.10		Started H ₂ O injection
7/31/09 11:09	40	62179.8	0.34		
7/31/09 11:31	40	62187.2	0.34		
7/31/09 11:46	40	62191.5	0.29		Disconnect tank, drain hoses, break down pump
7/31/09 12:00	--				Done w/clean-up until packer is pulled

FIELD INJECTION REFERENCE SHEET

WELL: EW-14b

Date/Time at start of injection: 7/22/2009; 7/28/2009; 7/29/2009

Weather conditions at start of injection:

Injection Fluid: Vegetable Oil

Injection personnel: Tim Wineland, Jen Hiatt, Mike Alowitz, Clint Oberbroeckling

Injection Pump: 3/4 HP

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/22/09 17:05	--	55847.6	--		Start gravity flow via drop tube to bottom 1st to go
7/22/09 17:12	--	55853.2	0.80	5.60	into well is leftover ~40 gal from EW-7b
7/22/09 17:17	--	55880.2	6.75	32.60	add
7/28/09 15:22	36	56079	--	32.60	Packer installed above screen (Batch 1)
7/28/09 15:28	34	56104	4.17	57.60	~5.5 GPM lg pump only
7/28/09 15:36	38	56143	4.88	96.60	just under 5 GPM
7/28/09 15:49	37	56205	4.77	158.60	stop injection @ 56208 to refill (Batch 1)
7/28/09 16:10	37	56376.5	8.17	158.60	restart injection, Nitrogen @2190 psi (Batch 2)
7/28/09 16:19	37	56421	4.94	203.10	
7/28/09 16:26	37	56455	4.86	237.10	~4.5 GPM
7/28/09 16:35	37	56495	4.44	277.10	~4.5 GPM DTW= 25.8'
7/28/09 16:41	37	56520.5	4.25	302.60	Batch 2 Stop
7/28/09 16:59	37	56688	--	302.60	Batch 3 Start
7/28/09 17:06	37	56721	4.71	335.60	DTW=25.8'
7/28/09 17:16	37	56764	4.30	378.60	DTW=25.8' ~4.5 GPM
7/28/09 17:28	37	56804	3.33	418.60	~4 GPM
7/28/09 17:32	37	56829	6.25	443.60	Batch 3 Stop
7/28/09 17:47	37	56987	--	443.60	Batch 4 Start DTW=25.8', 4.25 GPM, Nitrogen@2190
7/28/09 18:00	37	57042	4.23	498.60	~4 GPM
7/28/09 18:08	37	57074	4.00	530.60	~4 GPM, DTW=25.8'
7/28/09 18:16	37	57105	3.88	561.60	~4 GPM
7/28/09 18:20	37	57122	4.25	578.60	Batch 4 Stop
7/28/09 18:20	26	57122	--		Water injection start ~26 psi, 1 pump
7/28/09 18:25	40	57136	2.80		~5.5 GPM, 2nd pump turned on
7/28/09 18:42	--	57222	5.06		Water injection stop, ~100 gals
7/29/09 7:11	--	57430	7.17	578.60	Batch 5 Start, 4.25-4.5 GPM
7/29/09 7:19	38	57464	--	612.60	~4 GPM
7/29/09 7:29	38	57504	4.00	652.60	~4 GPM
7/29/09 7:39	38	57543	3.90	691.60	~4 GPM
7/29/09 7:47	38	57568	3.13	716.60	Stop Batch 5
7/29/09 8:04	38	57749	--	716.60	Start Batch 6 25.8' DTW, ~4 GPM
7/29/09 8:14	38	57778	2.90	745.60	~3.75 GPM
7/29/09 8:24	38	57816	--	783.60	~3.75 GPM
7/29/09 8:34	38	57855	3.90	822.60	~3.75 GPM
7/29/09 8:43	38	57886	3.44	853.60	Stop Batch 6
7/29/09 9:46	38	58039	--	853.60	Start Batch 7 ~4.25 GPM
7/29/09 9:56	38	58073	3.40	887.60	~4 GPM

FIELD INJECTION REFERENCE SHEET

WELL: EW-14b

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/29/09 10:06	38	58111	3.80	925.60	~3.75 GPM
7/29/09 10:16	38	58146	3.50	960.60	~3.5 GPM
7/29/09 10:23	38	58172.5	3.79	987.10	Stop Batch 7
7/29/09 10:39	38	58343.5	--	987.10	Start Batch 8, 4.3 GPM
7/29/09 10:51	38	58390	3.88	1033.60	~3.5-3.75 GPM
7/29/09 11:03	38	58427	3.08	1070.60	~3.25 GPM
7/29/09 11:15	38	58466	3.25	1109.60	~3.25 GPM
7/29/09 11:21	--	58484.5	3.08	1128.10	Stop Batch 8
7/29/09 11:34	--	58654	--	1128.10	Start Batch 9, ~3.25 GPM
7/29/09 11:47	38	58695	3.15	1169.10	~3 GPM
7/29/09 12:01	38	58735	2.86	1209.10	Just under 3 GPM
7/29/09 12:23	--	58795	2.73	1269.10	Stop Batch 9
7/29/09 12:38	--	59010	--	1269.10	Start Batch 10
7/29/09 12:41	38	59019	3.00	1278.10	~2.8 GPM
7/29/09 12:54	38	59052	2.54	1311.10	~2.7 GPM
7/29/09 13:10	38	59093	2.56	1352.10	~2.5 GPM
7/29/09 13:26	38	59131	2.38	1390.10	~2.4 GPM
7/29/09 13:43	38	59172	2.41	1431.10	~2.2 GPM
7/29/09 13:57	38	59202	2.14	1461.10	2.0-2.1 GPM, added more H ₂ O to mix tote
7/29/09 14:09	38	59228	2.17	1487.10	~2.3 GPM, almost all H ₂ O in mix tote
7/29/09 14:22	40	59250	1.69	--	Both pumps, 3.2 GPM
7/29/09 14:42	40	59318	3.40	--	~3.5 GPM
7/29/09 14:48	--	59341.5	3.92	--	Stop Water Injection

NOTES:

Batch 1-Batch 7: 20 Gallons Veg Oil, 120 Gallons H₂O

Batch 8&Batch 9: 40 Gallons Veg Oil, 100 Gallons H₂O

Batch 10: 135 gal H₂O, 54 gal Veg Oil

FIELD INJECTION REFERENCE SHEET

WELL: MW-115A

Date/Time at start of injection: 7/16/2009

Weather conditions at start of injection: 7/16 Sunny, 7/21 overcast/rain

Injection Fluid: Vegetable Oil

Injection personnel: Tim Wineland, Mike Alowitz, Jen Hiatt, Clint Oberbroeckling

Injection Pump: 3/4 HP and 1/2 HP in series

Reactive Media Injection

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/16/09 9:32	20	54107.8	--	0	21 psi @wellhead
7/16/09 9:33	24.5	54128	20.20	20.2	25 psi @wellhead
7/16/09 9:39	29	54195	11.17	87.2	29 psi @wellhead
7/16/09 9:39	30	--	--	--	Open ball valve all the way, no P drop
7/16/09 9:43	33	54238	--	130.2	33 psi @wellhead
7/16/09 9:51	33	54295	7.13	187.2	33 psi @wellhead
7/16/09 10:07	34-35	54384.5	5.59	276.7	36 psi @wellhead
7/16/09 10:16	35	54421	4.06	313.2	36 psi @wellhead
7/16/09 10:22	35	54442	3.50	334.2	36 psi @wellhead
7/16/09 10:32	36	54472	3.00	364.2	36.5 psi @wellhead ~365 GPH
7/16/09 10:45	36	54505	2.54	397.2	36 psi @wellhead
7/16/09 11:00	36	54546	2.73	438.2	36 psi @wellhead ~1.7 GPM
7/16/09 11:16	36-37	54565	1.19	457.2	35.5 psi @wellhead
7/16/09 11:49	38	54772.5	--	457.2	2nd Mix Tank Start
7/16/09 11:54	38	54780	1.88	464.7	38 psi @wellhead ~1.7 GPM
7/16/09 13:02	38	54865	1.25	549.7	38 psi @wellhead @13:32 42 gallons 0.5 hr
7/16/09 14:02	38	54933	1.13	617.7	38 psi @wellhead 68 Gal in Hr, Rate ~1 GPM
7/16/09 14:39	0	54960.8	0.75	645.5	Pump off, out of gas in generator
7/16/09 14:44	38	54961	--	645.7	Pump back on, 37psi@wellhead 0.8 GPM
7/16/09 15:27	--	54992	0.72	676.7	Stop pump to replumb in series
7/16/09 15:37	56@WH	54994	--	678.7	Restart, Running 2 pumps in series, 1.8 GPM
7/16/09 15:50	38	55014	1.54	698.7	Flow slowed considerably 0.8 GPM
7/16/09 15:59	57@WH		--		Small pump not running, plugged in, 1.7-1.8 GPM
7/16/09 16:55	--	55083	--	767.7	Only small pump running
7/16/09 16:57	57@WH	55085	1.00	769.7	Both pumps running
7/16/09 17:58	58@WH	55151	1.08	835.7	Both pumps running
7/16/09 18:26	--	--	--	--	Generator shutoff, turned off other generator
7/16/09 18:34	58@WH	55181.5	--	866.2	
7/16/09 19:00			--	866.2	Stop for day after lose packer
		55768	--	866.2	Hit valve on packer and it lost pressure
7/17/09 8:30	18	55769	--	867.2	Small pump on
7/17/09 8:33	58@WH	55769	0.00	867.2	Turn on big pump, w/only small pump not much flow
7/17/09 9:03	58@WH	55778	0.30	876.2	
7/17/09 9:10	56@WH	55780	0.29	878.2	0.7 GPM instantaneous
7/17/09 10:15	56@WH	55801.7	0.33	899.9	@10:45 instantaneous rate ~.2GPM or 11 GPH
7/17/09 11:15	57@WH	55813	0.19	911.2	
7/17/09 11:57	57@WH	55820	0.17	918.2	0.2 GPM

ACTION REFERENCE SHEET

WELL: MW-115A

Time	Pressure	Totalizer	Ave Flow		Notes (packer, etc)
7/17/09 12:33	56@WH	55825.8	0.16	924	0.2 GPM - Stop veg oil injection
7/17/09 12:39	58@WH	55825.8	--		Start a small flush water injection
7/17/09 15:00		55839	0.63		Stop flushwater
7/17/09 15:39					start siphon feed attempt
	--	58802.5	--		Start H2O only - want to see if we can get a
7/21/09 10:00			--		good flow rate - using drop tube on bottom of packer
7/21/09 10:01	15		--		small pump, injection H ₂ O
7/21/09 10:02			--		Start big pump too
7/21/09 10:03	58@WH	58804	--		
7/21/09 10:06	60@WH	58805	0.33		
7/21/09 10:25	61@WH	58808.8	0.20		
7/21/09 11:07	61@WH	58816.5	0.18		
7/21/09 12:16	61@WH	58836.5	0.29		
7/21/09 12:25	61@WH	58838.8	0.26		Stop active pumping of H ₂ O
7/21/09 12:31	--	58838.8	--	--	Start veg oil again
7/21/09 12:40	59@WH	58842.2	0.38	927.4	veg oil has at least reached wellhead
7/21/09 13:51	57@WH	58858	0.22	943.2	
7/21/09 14:40	57@WH	58866	0.16	951.2	39 minutes, 8 gallons
7/21/09 15:40	55.5@WH	58874	0.13	959.2	
7/21/09 15:45	55.5@WH	58874.6	0.12	959.8	Stop pumps - switch back to H ₂ O to flush hoses
7/21/09 15:50	--	--	--		Restart water
7/21/09 15:55	59.8@WH	58875.4	--		
7/21/09 16:30	61@WH	58878	0.07		Water off
7/21/09 17:40	--				Siphon in veg oil

NOTES:

 Jerry Tonneson, Nancy Swyers, Bill Pedicino on-site for start

 Planned for 450 gal veg oil

 53944.4 gallons on totalizer to flow -> 54094, ended @ 54088 (144)

 2nd tank H₂O filling 54565-54671 then rinse to 54680 w/rinse

 Mixing 2 totes into tank, pump to 54725 exactly

 Injection into 3rd mix tank - need to empty partial tote 54755 Actual 30 post rinse 54772.5

 Need to add 120 gal to 3rd mix tank still

 When 2 pumps run in series, gauge on flowmeter says 43 psi, wellhead says ~57 - trust wellhead

 7/17 @ well again - have to transfer 120 gal veg oil concentrate 55465 need to go to 55585

 went to 55586 - need to finish chase water - 55768

 Note if pumps stop pressure quickly drops to 0 @ wellhead, this indicates aquifer isn't

 pushing back w/that much force, H₂O doesn't flow backwards

FIELD INJECTION REFERENCE SHEET

WELL: MW-116A

Date/Time at start of injection: 7/29/2009

Weather conditions at start of injection: overcast

Injection Fluid: Vegetable Oil

Injection personnel: Clint Oberbroeckling, Jen Hiatt, Mike Alowitz

Injection Pump: 3/4 HP and 1/2 HP in series

Time	Pressure	Totalizer	Ave Flow	Vol	Notes (packer, etc)
7/22/09 10:25	Sm Pump	58878.1	--	0	*
7/22/09 10:27	18	58878.6	0.50	0.50	H ₂ O @ wellhead
7/22/09 10:30	18	58887.9	3.10	9.80	Turn on large pump
7/22/09 10:32	~55	58897.3	4.70	19.20	Tank Empty - 1st 30 gallon batch done
7/22/09 10:46	56	58899.2	--	21.10	Both pumps operating, 4.4 GPM right now
7/22/09 10:49	56	58912.6	4.47	34.50	About 3.8 GPM
7/22/09 10:51	--	58922.3	4.85	44.20	Out of fluid
7/22/09 11:08	--	58957.5	--	44.20	New batch - Mix 3:1 ratio pumps restarted
7/22/09 11:11	57-58	58968.5	3.67	55.20	2.6 GPM @ 11:15
7/22/09 11:16	58	58981.1	2.52	67.80	2.1 GPM @ 11:19
7/22/09 11:19	58	58989.2	2.70	75.90	1.9 GPM @ 11:23
7/22/09 11:27	58	59003.6	1.80	90.30	1.6 GPM @ 11:29
7/22/09 11:33	--	59012.0	1.68	98.70	
7/22/09 11:37	--	59017.8	1.45	104.50	Stop pumps out of liquid
7/22/09 11:48	59	59057	--	104.50	Pumps started after water
7/22/09 11:50	59	59061	2.00	108.50	1.4 GPM @ 11:51
7/22/09 12:01	58	59072.2	1.12	119.70	1.0 GPM @ 12:00
7/22/09 12:14	59	59083.7	0.88	131.20	0.8 GPM @ 12:15
7/22/09 12:32	59	59096	0.68	143.50	0.6 GPM @ 12:34
7/22/09 12:44	59	59102.6	0.55	150.10	0.45 GPM @ 12:46
7/22/09 12:58	59	59109.7	0.51	157.20	
7/22/09 13:01	--	59110.3	0.20	157.80	Running out of solution - shutoff pumps **
7/22/09 13:05	--	59110.3	--	0.00	Chase H ₂ O start
7/22/09 13:32	60	59110.8	0.02	0.50	only single pump so far, plug in large pump
7/22/09 13:46	60.5	59116.8	0.43	6.50	
7/22/09 14:00	61	59122.5	0.41	12.20	<25 gallons - want to get to at least 59135.3
7/22/09 14:40	61	59138.8	0.41	28.50	Stop pumps, 30 psi still on gauge

NOTES:

Injection material from MW-115A that was mixed but not able to inject

*Using potable H₂O from treatment plant & MW-116A veg oil/H₂O mix - mixing

at 2 parts H₂O to 1 part MW-115A water/veg oil mix

**Note pressure does not dissipate as fast as on MW-115A @13:04:00 still @10psi

FIELD INJECTION REFERENCE SHEET

WELL: MW-108B

Date/Time at start of injection: 7/15/2009, 15:17

Weather conditions at start of injection: windy

Injection Fluid: Permanganate

Injection personnel: Mike Alowitz, Tim Wineland

Injection Pump: 3/4 HP and 1/2 HP in series

Time	Pressure	~ Vol in Tank	Ave Flow	Notes (packer, etc)
7/15/09 15:20	--	340	--	Injection start - 340 gallons
7/15/09 15:20	29	--	--	using packer
7/15/09 15:24	31	280	15.00	
7/15/09 15:29	31	225	11.00	
7/15/09 15:29	35	225	--	
7/15/09 15:34	36	150	15.00	
7/15/09 15:37	36	110	13.33	Generator briefly surges down
7/15/09 15:41	35.5	60	12.50	
7/15/09 15:44	--	20	13.33	purge done - its not coming out any more
7/15/09 16:43	33	120	--	at MW-108B w/rinse water 4 drums
7/15/09 16:48	35	75	9.00	
7/15/09 16:54	--	0.0	12.50	tipped tank and made it work
7/15/09 17:01	--	--	--	Chase water injection start
7/15/09 17:06	32	150	--	Pump running full power
7/15/09 17:10	34.5	105	11.25	
7/15/09 17:17	34	20	12.14	
7/15/09 17:19	--	0	10.00	Pump done

NOTES: Chase water 150 Gallons

APPENDIX B



Client Name: MWH Americas, Inc.
Contact: Michael Alowitz
Address: 11153 Aurora Avenue
Des Moines, IA 50322

Page: Page 1 of 11
Lab Proj #: P1008353
Report Date: 10/21/10
Client Proj Name: Chemplex
Client Proj #: 1008616.0102

Laboratory Results

Total pages in data package: 12

<u>Lab Sample #</u>	<u>Client Sample ID</u>
P1008353-01	MW-108B
P1008353-02	MW-109B
P1008353-03	MW-112A
P1008353-04	MW-115A
P1008353-05	MW-116A
P1008353-06	MW-129
P1008353-07	EW-7B
P1008353-08	EW-14B
P1008353-09	DUP-1

Microseeps test results meet all the requirements of the NELAC standards or provide reasons and/or justification if they do not.

Approved By: Debbie Hallo **Date:** 10-21-10

Project Manager: Debbie Hallo

The analytical results reported here are reliable and usable to the precision expressed in this report. As required by some regulating authorities, a full discussion of the uncertainty in our analytical results can be obtained at our web site or through customer service. Unless otherwise specified, all results are reported on a wet weight basis.

*As a valued client we would appreciate your comments on our service.
Please call customer service at (412)826-5245 or email customerservice@microseeps.com.*

Client Name: MWH Americas, Inc.
Contact: Michael Alowitz
Address: 11153 Aurora Avenue
Des Moines, IA 50322

Page: Page 2 of 11
Lab Proj #: P1008353
Report Date: 10/21/10
Client Proj Name: Chemplex
Client Proj #: 1008616.0102

Case Narrative: Because of the dilutions required by the high concentrations of cis-dichloroethene, trichloroethene and tetrachloroethene it was not possible to measure the isotopic ratio of the trans-dichloroethene in these samples. Sample EW-7B had a coelution in the sample matrix that made it impossible to quantitate the isotopic ratio in the cis-dichloroethene. Every attempt was made to provide an accurate measurement of the isotopic ratio of the trichloroethene in that sample. While the result appeared acceptable, it should be used with a note of caution. The blank, LCS's, duplicate and surrogates were all close to or within the acceptance range and the data are reported as valid and representative of the samples as received.

Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

Page: Page 3 of 11
 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-108B	Water	P1008353-01	25 Aug. 10 14:10	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQI</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
CSIA						
cis-1,2-Dichloroethene	100.0	5	ug/L	Screen	9/1/10	hg
cis-1,2-Dichloroethene-area	3.81	1.0	Vs	AM24-AR_C	9/3/10	hg
cis-1,2-Dichloroethene-carbon	-18.84	-500.0	%	AM24-DL_C	9/3/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Surrogate-area	5.20	1.0	Vs	AM24-AR_C	9/3/10	hg
Surrogate-carbon	-37.45	-500.0	%	AM24-DL_C	9/3/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Tetrachloroethene	300.0	50	ug/L	Screen	9/14/10	hg
Tetrachloroethene-area	6.48	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	-23.09	-500.0	%	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	20.0	5	ug/L	Screen	9/1/10	hg
Trichloroethene-area	6.57	1.0	Vs	AM24-AR_C	9/8/10	hg
Trichloroethene-carbon	-22.42	-500.0	%	AM24-DL_C	9/8/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/8/10	hg
Vinyl Chloride	< 5	5	ug/L	Screen	9/1/10	hg
Vinyl Chloride-area	<1.0	1.0	Vs	AM24-AR_C	9/8/10	hg
Vinyl Chloride-carbon	NR	-500.0	%	AM24-DL_C	9/8/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/8/10	hg

Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-109B	Water	P1008353-02	25 Aug. 10 8:00	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQI</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<u>CSIA</u>						
cis-1,2-Dichloroethene	100.0	5	ug/L	Screen	9/1/10	hg
cis-1,2-Dichloroethene-area	4.44	1.0	Vs	AM24-AR_C	10/14/10	hg
cis-1,2-Dichloroethene-carbon	-19.21	-500.0	%	AM24-DL_C	10/14/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Surrogate-area	1.63	1.0	Vs	AM24-AR_C	10/14/10	hg
Surrogate-carbon	-37.09	-500.0	%	AM24-DL_C	10/14/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Tetrachloroethene	500.0	50	ug/L	Screen	9/14/10	hg
Tetrachloroethene-area	10.1	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	-22.25	-500.0	%	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	20.0	5	ug/L	Screen	9/1/10	hg
Trichloroethene-area	7.80	1.0	Vs	AM24-AR_C	9/8/10	hg
Trichloroethene-carbon	-21.68	-500.0	%	AM24-DL_C	9/8/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/8/10	hg
Vinyl Chloride	< 5	5	ug/L	Screen	9/1/10	hg
Vinyl Chloride-area	<1.0	1.0	Vs	AM24-AR_C	9/8/10	hg
Vinyl Chloride-carbon	NR	-500.0	%	AM24-DL_C	9/8/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/8/10	hg



Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-112A	Water	P1008353-03	25 Aug. 10 15:30	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>Ry</u>
CSIA						
cis-1,2-Dichloroethene	200.0	50	ug/L	Screen	9/14/10	hg
cis-1,2-Dichloroethene-area	4.93	1.0	Vs	AM24-AR_C	10/14/10	hg
cis-1,2-Dichloroethene-carbon	-18.42	-500.0	‰	AM24-DL_C	10/14/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Surrogate-area	1.53	1.0	Vs	AM24-AR_C	10/14/10	hg
Surrogate-carbon	-36.79	-500.0	‰	AM24-DL_C	10/14/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Tetrachloroethene	700.0	50	ug/L	Screen	9/14/10	hg
Tetrachloroethene-area	7.27	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	-23.52	-500.0	‰	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	40.0	5	ug/L	Screen	9/1/10	hg
Trichloroethene-area	15.1	1.0	Vs	AM24-AR_C	9/8/10	hg
Trichloroethene-carbon	-22.25	-500.0	‰	AM24-DL_C	9/8/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/8/10	hg
Vinyl Chloride	< 5	5	ug/L	Screen	9/1/10	hg
Vinyl Chloride-area	<1.0	1.0	Vs	AM24-AR_C	9/8/10	hg
Vinyl Chloride-carbon	NR	-500.0	‰	AM24-DL_C	9/8/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/8/10	hg



Client Name: MWH Americas, Inc.
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 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-115A	Water	P1008353-04	25 Aug. 10 11:00	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQI</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
CSIA						
cis-1,2-Dichloroethene	500.0	100	ug/L	Screen	9/1/10	hg
cis-1,2-Dichloroethene-area	11.9	1.0	Vs	AM24-AR_C	9/3/10	hg
cis-1,2-Dichloroethene-carbon	-21.68	-500.0	‰	AM24-DL_C	9/3/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Surrogate-area	3.65	1.0	Vs	AM24-AR_C	9/3/10	hg
Surrogate-carbon	-37.40	-500.0	‰	AM24-DL_C	9/3/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Tetrachloroethene	1000.0	100	ug/L	Screen	9/1/10	hg
Tetrachloroethene-area	15.8	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	-22.43	-500.0	‰	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	<100	100	ug/L	Screen	9/1/10	hg
Trichloroethene-area	5.23	1.0	Vs	AM24-AR_C	9/3/10	hg
Trichloroethene-carbon	-31.79	-500.0	‰	AM24-DL_C	9/3/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Vinyl Chloride	<100	100	ug/L	Screen	9/1/10	hg
Vinyl Chloride-area	1.44	1.0	Vs	AM24-AR_C	10/14/10	hg
Vinyl Chloride-carbon	-16.91	-500.0	‰	AM24-DL_C	10/14/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	10/14/10	hg

Client Name: MWH Americas, Inc.
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 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-116A	Water	P1008353-05	25 Aug. 10 12:15	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQI</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<u>CSIA</u>						
cis-1,2-Dichloroethene	400.0	50	ug/L	Screen	9/14/10	hg
cis-1,2-Dichloroethene-area	17.5	1.0	Vs	AM24-AR_C	9/3/10	hg
cis-1,2-Dichloroethene-carbon	-18.69	-500.0	‰	AM24-DL_C	9/3/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Surrogate-area	3.38	1.0	Vs	AM24-AR_C	9/3/10	hg
Surrogate-carbon	-37.23	-500.0	‰	AM24-DL_C	9/3/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	9/3/10	hg
Tetrachloroethene	10.0	5	ug/L	Screen	9/1/10	hg
Tetrachloroethene-area	5.90	1.0	Vs	AM24-AR_C	9/8/10	hg
Tetrachloroethene-carbon	-21.11	-500.0	‰	AM24-DL_C	9/8/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	9/8/10	hg
Trichloroethene	< 5	5	ug/L	Screen	9/1/10	hg
Trichloroethene-area	2.07	1.0	Vs	AM24-AR_C	9/8/10	hg
Trichloroethene-carbon	-19.32	-500.0	‰	AM24-DL_C	9/8/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/8/10	hg
Vinyl Chloride	20.0	5	ug/L	Screen	9/1/10	hg
Vinyl Chloride-area	5.74	1.0	Vs	AM24-AR_C	9/8/10	hg
Vinyl Chloride-carbon	-26.26	-500.0	‰	AM24-DL_C	9/3/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/8/10	hg



Client Name: MWH Americas, Inc.
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 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
MW-129	Water	P1008353-06	25 Aug. 10 10:00	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>Ry</u>
CSIA						
cis-1,2-Dichloroethene	1000.0	200	ug/L	Screen	9/14/10	hg
cis-1,2-Dichloroethene-area	7.18	1.0	Vs	AM24-AR_C	9/4/10	hg
cis-1,2-Dichloroethene-carbon	-16.83	-500.0	‰	AM24-DL_C	9/4/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Surrogate-area	3.06	1.0	Vs	AM24-AR_C	9/4/10	hg
Surrogate-carbon	-36.63	-500.0	‰	AM24-DL_C	9/4/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Tetrachloroethene	5000.0	200	ug/L	Screen	9/14/10	hg
Tetrachloroethene-area	12.3	1.0	Vs	AM24-AR_C	9/4/10	hg
Tetrachloroethene-carbon	-22.26	-500.0	‰	AM24-DL_C	9/4/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Trichloroethene	300.0	200	ug/L	Screen	9/14/10	hg
Trichloroethene-area	1.46	1.0	Vs	AM24-AR_C	9/4/10	hg
Trichloroethene-carbon	-21.25	-500.0	‰	AM24-DL_C	9/4/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Vinyl Chloride	700.0	200	ug/L	Screen	9/14/10	hg
Vinyl Chloride-area	1.77	1.0	Vs	AM24-AR_C	9/4/10	hg
Vinyl Chloride-carbon	-23.70	-500.0	‰	AM24-DL_C	9/4/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/4/10	hg



N - NELAC certified analysis

PA02-00538

Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
EW-7B	Water	P1008353-07	26 Aug. 10 7:40	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<u>CSIA</u>						
cis-1,2-Dichloroethene	<50	50	ug/L	Screen	9/16/10	hg
cis-1,2-Dichloroethene-area	<1.0	1.0	Vs	AM24-AR_C	10/1/10	hg
cis-1,2-Dichloroethene-carbon	NR	-500.0	‰	AM24-DL_C	10/1/10	hg
cis-1,2-Dichloroethene-Co-elution	Yes	0.0	NA	8260B	10/1/10	hg
Surrogate-area	4.00	1.0	Vs	AM24-AR_C	10/1/10	hg
Surrogate-carbon	-37.80	-500.0	‰	AM24-DL_C	10/1/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	10/1/10	hg
Tetrachloroethene	90.0	50	ug/L	Screen	9/16/10	hg
Tetrachloroethene-area	1.89	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	-25.26	-500.0	‰	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	2000.0	100	ug/L	Screen	9/1/10	hg
Trichloroethene-area	1.64	1.0	Vs	AM24-AR_C	10/1/10	hg
Trichloroethene-carbon	-35.98	-500.0	‰	AM24-DL_C	10/1/10	hg
Trichloroethene-Co-elution	Yes	0.0	NA	8260B	10/1/10	hg
Vinyl Chloride	<50	50	ug/L	Screen	9/16/10	hg
Vinyl Chloride-area	4.78	1.0	Vs	AM24-AR_C	10/14/10	hg
Vinyl Chloride-carbon	-35.61	-500.0	‰	AM24-DL_C	10/14/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	10/14/10	hg

Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

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 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
EW-14B	Water	P1008353-08	26 Aug. 10 9:40	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
CSIA						
cis-1,2-Dichloroethene	300.0	50	ug/L	Screen	9/16/10	hg
cis-1,2-Dichloroethene-area	2.08	1.0	Vs	AM24-AR_C	10/14/10	hg
cis-1,2-Dichloroethene-carbon	-16.97	-500.0	%	AM24-DL_C	10/14/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Surrogate-area	11.1	1.0	Vs	AM24-AR_C	10/14/10	hg
Surrogate-carbon	-36.36	-500.0	%	AM24-DL_C	10/14/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Tetrachloroethene	<50	50	ug/L	Screen	9/16/10	hg
Tetrachloroethene-area	<1.0	1.0	Vs	AM24-AR_C	10/14/10	hg
Tetrachloroethene-carbon	NR	-500.0	%	AM24-DL_C	10/14/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Trichloroethene	<50	50	ug/L	Screen	9/16/10	hg
Trichloroethene-area	<1.0	1.0	Vs	AM24-AR_C	10/14/10	hg
Trichloroethene-carbon	NR	-500.0	%	AM24-DL_C	10/14/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	10/14/10	hg
Vinyl Chloride	60.0	5	ug/L	Screen	9/16/10	hg
Vinyl Chloride-area	5.48	1.0	Vs	AM24-AR_C	10/1/10	hg
Vinyl Chloride-carbon	-17.34	-500.0	%	AM24-DL_C	10/1/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	10/1/10	hg

Client Name: MWH Americas, Inc.
 Contact: Michael Alowitz
 Address: 11153 Aurora Avenue
 Des Moines, IA 50322

Page: Page 11 of 11
 Lab Proj #: P1008353
 Report Date: 10/21/10
 Client Proj Name: Chemplex
 Client Proj #: 1008616.0102

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>	<u>Sampled Date/Time</u>	<u>Received</u>		
DUP-1	Water	P1008353-09	25 Aug. 10 0:00	30 Aug. 10 10:23		
<u>Analyte(s)</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
CSIA						
cis-1,2-Dichloroethene	1000.0	50	ug/L	Screen	9/14/10	hg
cis-1,2-Dichloroethene-area	67.9	1.0	Vs	AM24-AR_C	9/4/10	hg
cis-1,2-Dichloroethene-carbon	-16.82	-500.0	%	AM24-DL_C	9/4/10	hg
cis-1,2-Dichloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Surrogate-area	2.45	1.0	Vs	AM24-AR_C	9/4/10	hg
Surrogate-carbon	-37.24	-500.0	%	AM24-DL_C	9/4/10	hg
Surrogate-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Tetrachloroethene	5400 E	50	ug/L	Screen	9/14/10	hg
Tetrachloroethene-area	114	1.0	Vs	AM24-AR_C	9/4/10	hg
Tetrachloroethene-carbon	-21.96	-500.0	%	AM24-DL_C	9/4/10	hg
Tetrachloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Trichloroethene	330	50	ug/L	Screen	9/14/10	hg
Trichloroethene-area	13.8	1.0	Vs	AM24-AR_C	9/4/10	hg
Trichloroethene-carbon	-21.08	-500.0	%	AM24-DL_C	9/4/10	hg
Trichloroethene-Co-elution	No	0.0	NA	8260B	9/4/10	hg
Vinyl Chloride	670	50	ug/L	Screen	9/14/10	hg
Vinyl Chloride-area	18.6	1.0	Vs	AM24-AR_C	9/4/10	hg
Vinyl Chloride-carbon	-22.95	-500.0	%	AM24-DL_C	9/4/10	hg
Vinyl Chloride-Co-elution	No	0.0	NA	8260B	9/4/10	hg



Microseeps
Lab. Proj. #

1008353

CHAIN - OF - CUSTODY RECORD

Microseeps
COC cont. #

707

Phone: (412) 826-5245

Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238

Fax No.: (412) 826-3433

Company :

MWH

Co. Address :

11153 AURORA AVE, URBANA, IL 61856

Phone # :

515,253,0830 Fax #: 515,253,9592

Proj. Manager :

Jen Hiatt

Proj. Name/Number :

Chemplex 1008616.0102

Sampler's signature :

Clint Ober

Cooler Temp.

4°C 01/22/02

Parameters Requested

Results to : MWH

Invoice to : MWH
Reference Job #

Sample ID	Sample Description	Sample Type Water Vapor Solid	Date	Time	Notes	Remarks
MW-108B		X	8/25/0	1410	9	IF Daugherty products
MW-109B				800	9	Not Present, NO CSIA
MW-112A				1530	9	Analysis - except TCE, PCE
MW-115A				1100	9	CIS-1,2-PCE & little else
MW-116A				1215	9	
MW-129A				1000	9	
MW-81B-EW-7B			8/24/10	940	9	
EW-7C-EW-14B			8/24/10	940	9	
DUP-1			8/25/10	—	9	

Relinquished by :	Company : MWH	Date : 8/26/10	Time : 1230	Received by :	Company :	Date : 8/27	Time : 1100
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

WHITE COPY : Accompany Samples

YELLOW COPY : Laboratory File

PINK COPY : Submitter

APPENDIX C



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 7
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

JUL 30 2010

RECEIVED

AUG 4 2010

ERLER & KALINOWSKI, INC.

Mr. Mark Hendrickson
Project Manager
Chevron Environmental Management Company
Superfund and Property Management Business Unit
4800 Fournace Place, Room E534C
Bellaire, Texas 77401

RE: Chemplex Site, OU No.1
Clinton, IA

Dear Mr. Hendrickson:

We have completed review of the "Hot Spot Pilot Test 6-Month Progress Report" dated May 2010, prepared by your consultant, MWH.

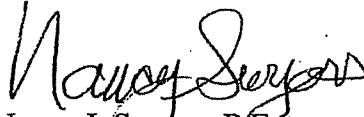
EPA Region 7 has one comment on page 11, Section 4.2 of the report in regard to MW-108B and MW-112A. The report states there doesn't appear to be any interconnection between MW-108B, the well injected with permanganate, and downgradient well MW-112A. Based on the last data on MW-112A prior to the permanganate injection, tetrachloroethene (PCE) dropped from 800 to 560 micrograms per liter (ug/L). This may be the result of the variability of yearly sampling or it may be the result of an up-gradient decrease of PCE as a result of the permanganate injection. Additionally, if the wells are not connected hydrologically, it is difficult to expect a downgradient reduction of PCE. There are wells in the present monitoring system which may be interconnected. These wells may be a better choice to determine downgradient effects of both vegetable oil and permanganate injections. We believe that both permanganate and vegetable oil injections make sense at this site. Vegetable oil injections may be a more useful choice for a long term reduction of contaminants while permanganate appears to be a better choice for acute reduction of contamination for a short period of time.

Also, enclosed with this letter is a memorandum with comments on the report from EPA's National Risk Management Research Laboratory in Ada, Oklahoma.

The report states that the Evaluation Report will be prepared and submitted to EPA later this year after an additional round of samples are collected. All EPA comments must be addressed in this Evaluation Report.

If you have any questions or comments or wish to discuss these comments, you may contact me at 913-551-7703.

Sincerely,

A handwritten signature in black ink, appearing to read "Nancy Swyers".

Nancy J. Swyers, P.E.
Remedial Project Manager
Iowa/Nebraska Remedial Branch
Superfund Division

Enclosure

cc: Cal Lundberg, IDNR (w/enclosure)
Tom Belick, EKI (w/enclosure)



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
GROUND WATER AND ECOSYSTEMS RESTORATION DIVISION
PO BOX 1198 • ADA, OK 74820

RECEIVED

JUL 08 2010

June 29, 2010

SUPERFUND DIVISION

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Review Comments Regarding "Hot Spot Pilot Test 6-Month Progress Report" prepared for the Chemplex Site in Clinton, IA.
(10-R07-001)

FROM: Ann Keeley, Acting Chief
Ecosystem and Subsurface Protection Branch

TO: Nancy Swyers, RPM
U.S. EPA Region 7

The following comments are offered with respect to the subject document, dated May 2010, which provides a summary of activities to assess the viability of an in situ treatment technology to address areas of elevated (hot spots) PCE concentrations. At this early point, after the injection of oil and permanganate injection began, it is doubtful that significant and meaningful conclusions can be made. The following comments are offered in support of this position.

Five wells were used to inject vegetable oil and one was used for the injection of permanganate. This is not meant to imply a fault in the system as permanganate was added late in the game at the suggestion of EPA. The point is that even with this limited opportunity of comparing the two treatment alternatives; it was reasonably concluded in the report that permanganate might have a slight edge, if for no other reason, reduced conductivity resulting from the oil injections. It should also be pointed out that about 75% of the data included in the report reflected remedial progress only after a little more than three months after injection began. This is almost always too early, in a field-scale demonstration, for drawing meaningful conclusions. The remainder of the data was collected 6 months after injection began which is also early in many cases.

Figure 1 shows three monitoring wells, however, the Table of Contents lists only two which are downgradient of MW-115A and MW-108B. Section 4.0 states that MW-109B and MW-129A are downgradient of injection well MW-115A, and MW-112A is down gradient from injection well MW-108B. This seems to be an anomaly. Since MW-129A is south of MW-115A and NW-112A is south and slightly west of MW-108B, it would appear that MW-109B would more likely be a monitoring wells for EW-14b than MW-115A. The point of all of this is that the flow lines, lateral dispersion, injection radius of

influence of a few feet, and distance between the two wells play very important roles in determining if the monitoring wells actually have continuity with the injection wells. The time that may be required for the injected fluid to reach the monitoring wells is also important in making conclusions concerning the biological processes that are taking place. For example, for injected fluid to reach MW-109B and MW-112A in six months the ground-water velocity would have to be significantly greater than 1 ft/day which, although possible, would be unusual. In other words, sampling the monitoring wells may be an expensive waste unless continuity and time of travel can be established.

With respect to the chlorinated compounds, there seems to be little doubt that, with a few exceptions, attenuation is taking place to various degrees within the well bores, with oil seemingly a little better than permanganate. But it would not be proper to finalize this conclusion at this point as there are five oil injection results with only one permanganate observation. There appears to be as much variation between the five oil injections as there is between the oil and permanganate observations.

At this point there does not seem to be any concrete conclusions that can be taken from the monitoring well information; even at MW-129A which is the closest to an injection well.

The attached table is a summary of the available isotope analysis. It seems that this approach will show great promise in the future. But with the available data not a great deal can be inferred other than the most active biological finding is in NW-116A with respect to Trichloroethene and the least at EW-14b with respect to Perchloroethene.

Hopefully data gathered between now and the latter part of 2010 will be more meaningful. It would be helpful if additional information could be obtained with respect to the comparison of vegetable oil and permanganate remediations alternatives.

Once again, thank you for the opportunity of working with you during remediation activities at the Chemplex Site. If you have any questions or would like to discuss these comments further, please do not hesitate to contact me at your convenience (phone: 580-436-8890, email keeley.ann@epa.gov).

cc: Linda Fiedler (5203P)
Robert Weber, Region 7
Dave Drake, Region 7
Lisa Gotto, Region 7
Jeff Johnson, Region 7
Dan Nicoski, Region 7
Bill Pedicino, Region 7
Brian Zurbuchen, Region 7

Isotope Analysis Chemplex Site Hot Spot Test

Site	Activity	Compound	Base	Period	Value	Delta %
NW-116A	Inj. Oil	Per	-21.18	3 Month	-22.27	5.1 +
		Tri	-19.94	3 Month	-32.29	61.9 +
		Cis	-15.76	3 Month	-18.18	15.3 +
EW-7b	Inj. Oil	Per	-25.5	3 Month	-25.03	1.8 -
EW-14b	Inj. Oil	Per	-21.62	3 Month	-18.68	13.0 -
		Tri	-19.61	3 Month	-20.69	5.5 +
		cis	-14.62	3 Month	-20.04	37.1 +
		VC	-19.81	3 Month	-20.76	4.8 +
MW-109B	Monitoring	Per	-21.82	3 Month	-22.11	1.3+
		Tri	-20.41	3 Month	-21017	3.7 +
		cis	-18.8	3 Month	-18.62	1.0 -

APPENDIX B:

**PME Plan Addendum 2, prepared by MWH Americas, Inc.,
dated 7 April 2011**

**MWH**

BUILDING A BETTER WORLD

TECHNICAL MEMORANDUM

Date:	April 7, 2011	Reference:	1010756
To:	Nancy Swyers, EPA Bill Pedicino, EPA	cc:	Mark Hendrickson, Chevron Preston Turner, Citigroup Tom Belick, EKI Dave Umezaki, EKI Jeff Coon, MWH
From:	Jennifer Hiatt, MWH		
Subject:	PME Plan Addendum 2 Chemplex Site – 2011 Sampling and Gauging Schedule		

This Technical Memorandum (Tech Memo) has been prepared as Performance Monitoring Evaluation (PME) Addendum 2, to provide the 2011 gauging and sampling plan for the Chemplex site in Clinton, Iowa. The PME Plan (MWH, 2008), dated October 2008 (PME Plan), presented the groundwater monitoring and gauging schedule for 2008 and 2009, following the September 2008 shutdown of the groundwater pump-and-treat system; PME Addendum 1 provided a gauging and sampling schedule for 2010. In accordance with the PME Plan, the gauging and sampling schedule for 2011 has been revised following a review of data collected in 2008, 2009, and 2010. On March 3, 2011, the United States Environmental Protection Agency (EPA), MWH, Erler & Kalinowski, Inc. (EKI), and ACC/GCC participated in a conference call to review 2008, 2009, and 2010 groundwater monitoring data; and establish the 2011 monitoring plan. This Tech Memo presents the jointly agreed-upon sampling and gauging schedules for 2011.

GROUNDWATER SAMPLING

The 2011 groundwater sampling program at the Chemplex site will consist of two large-scale sampling events in the second and fourth quarters of 2011 (approximately May and November). Table 3-1 lists the wells and sampling schedule for 2011. Table 3-1 updates the same numbered table in the PME Plan. Sampling locations are on an annual or biannual sampling schedule.

Figures presented in the PME Plan have been updated to reflect the 2011 sampling schedule. The figures show the sampling locations by geologic unit and Figures 3-2 through 3-7 correspond to the figures of the PME Plan for the same geologic units.

Surface water sampling locations SW-1 through SW-4 are scheduled for biannual sampling in 2011. A private residential well west of the Chemplex site is sampled annually. Equistar production wells are sampled biennially in odd-numbered years and will be sampled in 2011.

All monitoring locations will be sampled for volatile organic compounds (VOCs). Polynuclear aromatic hydrocarbons (PAHs) will be analyzed in samples from surface water point SW-1, the

private residential well, and the Equistar production wells. To evaluate natural attenuation related to the Hot Spot Pilot Study, total organic carbon will be sampled from select wells as indicated in Table 3-1.

WATER LEVEL GAUGING

Two site-wide water level gauging events will be completed in 2011. Gauging locations are indicated in Table 3-1, and Figures 3-2 through 3-7. Gauging locations were selected to support continued evaluation of groundwater conditions following shutdown of the pump-and-treat system. Those wells in which vegetable oil was injected may be excluded from gauging due to accumulated vegetable oil, which leads to a nonrepresentative reading of groundwater elevation.

SAMPLING PROCEDURES AND PROTOCOLS

The sampling procedures and protocols will be in accordance with the PME Plan, Quality Assurance Project Plan, Chemplex Site, Clinton, Iowa (MWH, 2008) (QAPP). Procedures may be modified, as needed, based on site conditions or the conditions of the wells in the sampling plan.

REVIEW OF 2011 DATA

Similar to the procedure completed with the March 3, 2011 conference call to review the 2010 data and agree on the 2011 sampling schedule, a data review meeting will be conducted in February or March of 2012 to review the 2011 data. The data review meeting will also be used to establish the sampling plan for 2012.

/jah:vas

Attachments

Table 3-1 Monitoring Plan for 2011

Figure 3-2 Overburden Monitoring Locations For 2011

Figure 3-3 Upper Scotch Grove Monitoring Locations For 2011

Figure 3-4 Lower Scotch Grove Monitoring Locations For 2011

Figure 3-5 Farmers Creek Monitoring Locations For 2011

Figure 3-6 Lower Hopkinton Monitoring Locations For 2011

Figure 3-7 Blanding Monitoring Locations for 2011

TABLE 3-1
MONITORING PLAN FOR 2011
CHEMPLEX SITE

Sample Location	Geologic Unit	Gauging Frequency	Sampling Frequency	Sampling Events		Analytes
				Q2	Q4	
Existing Monitoring Wells						
3	OVB	Biannual	Biannual	X	X	VOCs
3A	OVB	Biannual	None			
4	OVB	Biannual	None			
ARC MW-1	OVB	Biannual	None			
ARC MW-2	OVB	Biannual	None			
ARC MW-8	OVB	Biannual	None			
ARC MW-14	OVB	Biannual	None			
ARC MW-200B	LSG	Biannual	Biannual	X	X	VOCs
ARC MW-200C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-200D	LH	Biannual	Biannual	X	X	VOCs
ARC MW-201B	LSG	Biannual	Biannual	X	X	VOCs
ARC MW-201C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-205B	LSG	Biannual	Biannual	X	X	VOCs
ARC MW-205C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-205D	BL	Biannual	Annual	X		
ARC MW-206B	LSG	Biannual	Biannual	X	X	VOCs
ARC MW-207B	LSG	Biannual	Biannual	X	X	VOCs
ARC MW-207C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-208B	LSG	Biannual	Annual	X		VOCs
ARC MW-208C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-209BC	LSG/FC	Biannual	Biannual	X	X	VOCs
ARC MW-210BC	LSG/FC	Biannual	None			
ARC MW-211B	LSG	Biannual	None			
ARC MW-211C	FC	Biannual	Biannual	X	X	VOCs
ARC MW-212B	LSG	Biannual	None			
ARC MW-212C	FC	Biannual	None			
DAC-1	OVB/USG	Biannual	None			
DG-16	USG	Biannual	Biannual	X	X	VOCs
DG-17B	USG	Biannual	None			
DG-18B	LSG	Biannual	Biannual	X	X	VOCs
DG-19B	USG	Biannual	None			
DG-21B	USG	Biannual	Biannual	X	X	VOCs
DG-21C	LSG	Biannual	Biannual	X	X	VOCs
MW-4	OVB	Biannual	None			
MW-18B	USG	Biannual	Annual	X		VOCs
MW-18C	LSG	Biannual	Annual	X		VOCs
MW-19B	USG	Biannual	None			
MW-30B	USG	Biannual	None			
MW-53A	OVB	Biannual	Biannual	X	X	VOCs
MW-56	FC	Biannual	Annual	X		VOCs
MW-56-1	USG	Biannual	Annual	X		VOCs
MW-57	BL	Biannual	Annual	X		VOCs
MW-57-1	USG	Biannual	Biannual	X	X	VOCs
MW-58	USG	Biannual	None			
MW-70	BL	Biannual	Annual	X		VOCs
MW-73	BL	Biannual	Biannual	X	X	VOCs
MW-73-1	FC	Biannual	None			
MW-73-2	LSG	Biannual	None			
MW-74-1	LSG	Biannual	None			
MW-81B	LSG	Biannual	None			
MW-81C	FC	Biannual	None			
MW-82B	LSG	Biannual	Biannual	X	X	VOCs
MW-82C	FC	Biannual	Biannual	X	X	VOCs
MW-83B	LSG	Biannual	None			
MW-83C	FC	Biannual	None			
MW-85B	LSG	Biannual	Biannual	X	X	VOCs
MW-85C	FC	Biannual	Biannual	X	X	VOCs
MW-85D	BL	Biannual	None			
MW-87A	USG	Biannual	None			

TABLE 3-1
MONITORING PLAN FOR 2011
CHEMPLEX SITE

Sample Location	Geologic Unit	Gauging Frequency	Sampling Frequency	Sampling Events		Analytes
				Q2	Q4	
Existing Monitoring Wells (continued)						
MW-94A	OVB	Biannual	Annual	X		VOCs
MW-97A	USG	Biannual	Biannual	X	X	VOCs
MW-97B	LSG	Biannual	None			
MW-97C	FC	Biannual	Annual	X		VOCs
MW-99A	OVB	Biannual	Biannual	X	X	VOCs
MW-102E	BL	Biannual	None			
MW-103B	LSG	Biannual	Biannual	X	X	VOCs
MW-103C	FC	Biannual	Biannual	X	X	VOCs
MW-103D	BL	Biannual	Biannual	X	X	VOCs
MW-104B	LSG	Biannual	Annual	X		VOCs
MW-104C	FC	Biannual	Annual	X		VOCs
MW-104D	BL	Biannual	Annual	X		VOCs
MW-105B	LSG	Biannual	Biannual	X	X	VOCs
MW-105C	FC	Biannual	Biannual	X	X	VOCs
MW-105D	BL	Biannual	None			
MW-106A	USG	Biannual	Biannual	X	X	VOCs
MW-106B	LSG	Biannual	Biannual	X	X	VOCs
MW-106C	FC	Biannual	Biannual	X	X	VOCs
MW-107A	OVB	Biannual	Biannual	X	X	VOCs
MW-107B	LSG	Biannual	Biannual	X	X	VOCs
MW-107C	FC	Biannual	Biannual	X	X	VOCs
MW-108B	LSG	Biannual	Biannual	X	X	VOCs
MW-108C	FC	Biannual	Biannual	X	X	VOCs
MW-109B	LSG	Biannual	Biannual	X	X	VOCs
MW-109C	FC	Biannual	Biannual	X	X	VOCs
MW-110B	LSG	Biannual	Biannual	X	X	VOCs
MW-111B	LSG	Biannual	None			
MW-112A	LSG	Biannual	Annual	X		VOCs, NAA
MW-113A	LSG	Biannual	Biannual	X	X	VOCs
MW-115A	LSG	Biannual	None			
MW-116A	LSG	Biannual	Biannual	X	X	VOCs, NAA
MW-117B	LSG	Biannual	Annual	X		VOCs
MW-117C	FC	Biannual	Biannual	X	X	VOCs
MW-118C	FC	Biannual	Annual	X		VOCs
MW-119A	OVB	Biannual	Biannual	X	X	VOCs
MW-119B	LSG	Biannual	Biannual	X	X	VOCs
MW-119C	FC	Biannual	Biannual	X	X	VOCs
MW-120A	OVB	Biannual	Biannual	X	X	VOCs
MW-120B	LSG	Biannual	Biannual	X	X	VOCs
MW-121A	OVB	Biannual	Biannual	X	X	VOCs
MW-121B	LSG	Biannual	Biannual	X	X	VOCs
MW-121C	FC	Biannual	Biannual	X	X	VOCs
MW-122A	OVB	Biannual	Biannual	X	X	VOCs
MW-122B	LSG	Biannual	Biannual	X	X	VOCs
MW-122C	FC	Biannual	Biannual	X	X	VOCs
MW-129A	LSG	Biannual	Biannual	X	X	VOCs
Private Wells						
Munck Residence	Unknown	Not Gauged	Annual	X		VOCs, PAHs
WELL1Q	OD	Not Gauged	Odd Years Only	X		VOCs, PAHs
WELL4Q	OD	Not Gauged	Odd Years Only	X		VOCs, PAHs
WELL6Q	OD	Not Gauged	Odd Years Only	X		VOCs, PAHs
WELL7Q	OD	Not Gauged	Odd Years Only	X		VOCs, PAHs
Existing Extraction Wells						
PB-2	OVB	Biannual	None			
PT/RW-1	OVB	Biannual	None			
EW-3a	USG	When Sampled	Annual		X	VOCs, NAA
EW-6b	FC	Biannual	None			
EW-6c	LH	Biannual	Biannual	X	X	VOCs
EW-7a	USG	Biannual	Biannual	X	X	VOCs
EW-7b	FC	When Sampled	Annual		X	VOCs, NAA
EW-7c	LH	Biannual	None			
EW-8a	USG	Biannual	None			

TABLE 3-1
MONITORING PLAN FOR 2011
CHEMPLEX SITE

Sample Location	Geologic Unit	Gauging Frequency	Sampling Frequency	Sampling Events		Analytes
				Q2	Q4	
Existing Extraction Wells (continued)						
EW-10a	USG	Biannual	None			
EW-11a	USG	Biannual	Biannual	X	X	VOCs
EW-11b	FC	Biannual	Biannual	X	X	VOCs
EW-11c	LH	Biannual	Annual	X		VOCs
EW-13b	FC	Biannual	Annual	X		VOCs
EW-13c	LH	Biannual	None			
EW-14b	FC	Biannual	Annual		X	VOCs, NAA
EW-14c	LH	Biannual	Biannual	X	X	VOCs
EW-15a	USG	Biannual	None			
EW-16c	LH	Biannual	None			
EW-18a	USG	Biannual	None			
EW-19a	USG	Biannual	None			
LF-2	OVB/USG	Biannual	None			
LF-4	OVB/USG	Biannual	None			
LF-6	OVB/USG	Biannual	None			
Surface Water Monitoring Locations						
SW-1	-	Not Gauged	Biannual	X	X	VOCs, PAHs
SW-2	-	Not Gauged	Biannual	X	X	VOCs
SW-3	-	Not Gauged	Biannual	X	X	VOCs
SW-4	-	Not Gauged	Biannual	X	X	VOCs

Notes:

BL = Blanding

FC = Farmers Creek

LH = Lower Hopkinton

LSG = Lower Scotch Grove

NAA = Natural attenuation analyte, total organic carbon.

OVB = Overburden

OD = Ordovician Dolomites and sandstones, located below the Maquoketa Shale layer.

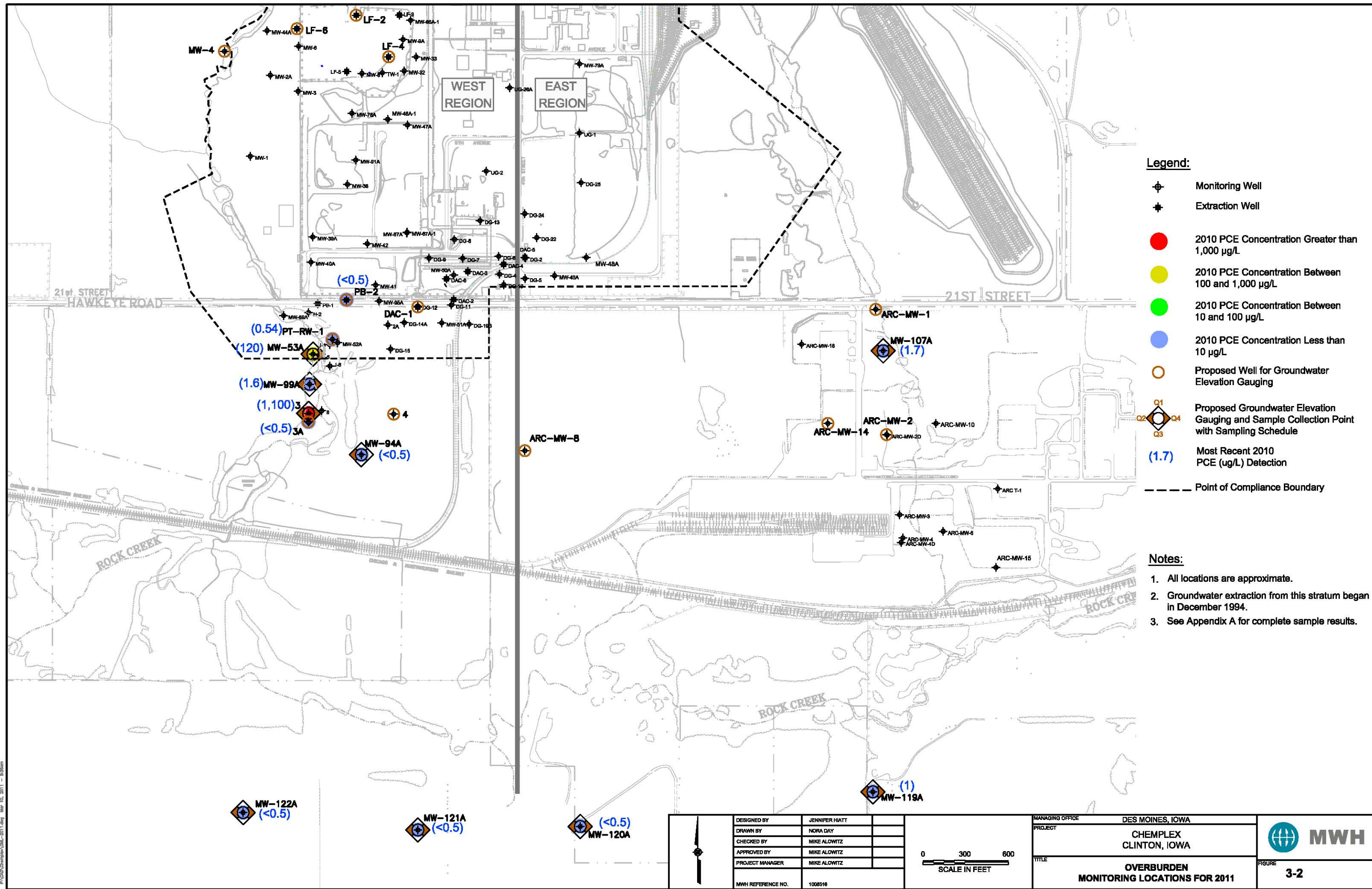
PAHs = Polynuclear aromatic hydrocarbons.

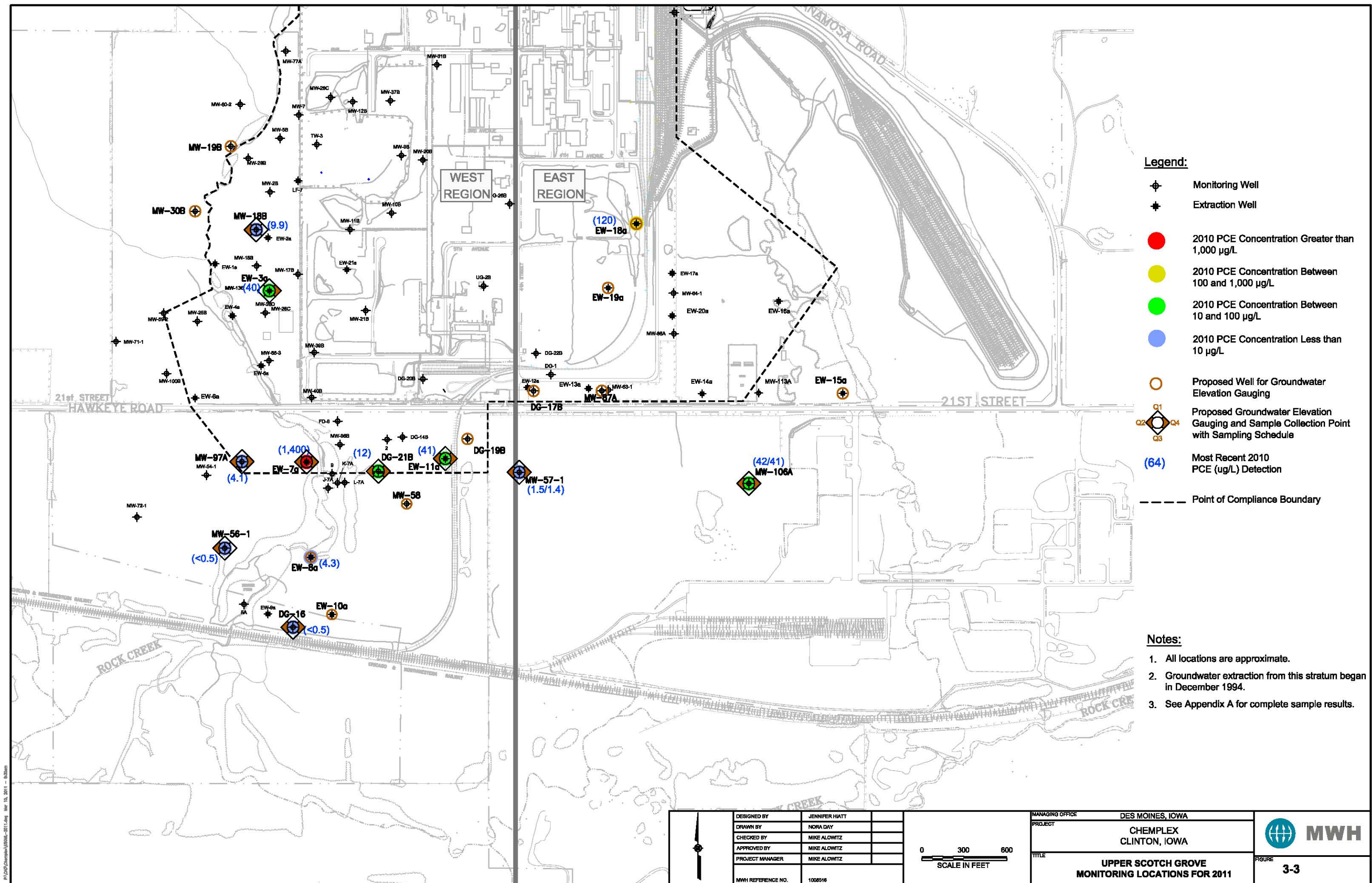
Q = Quarter

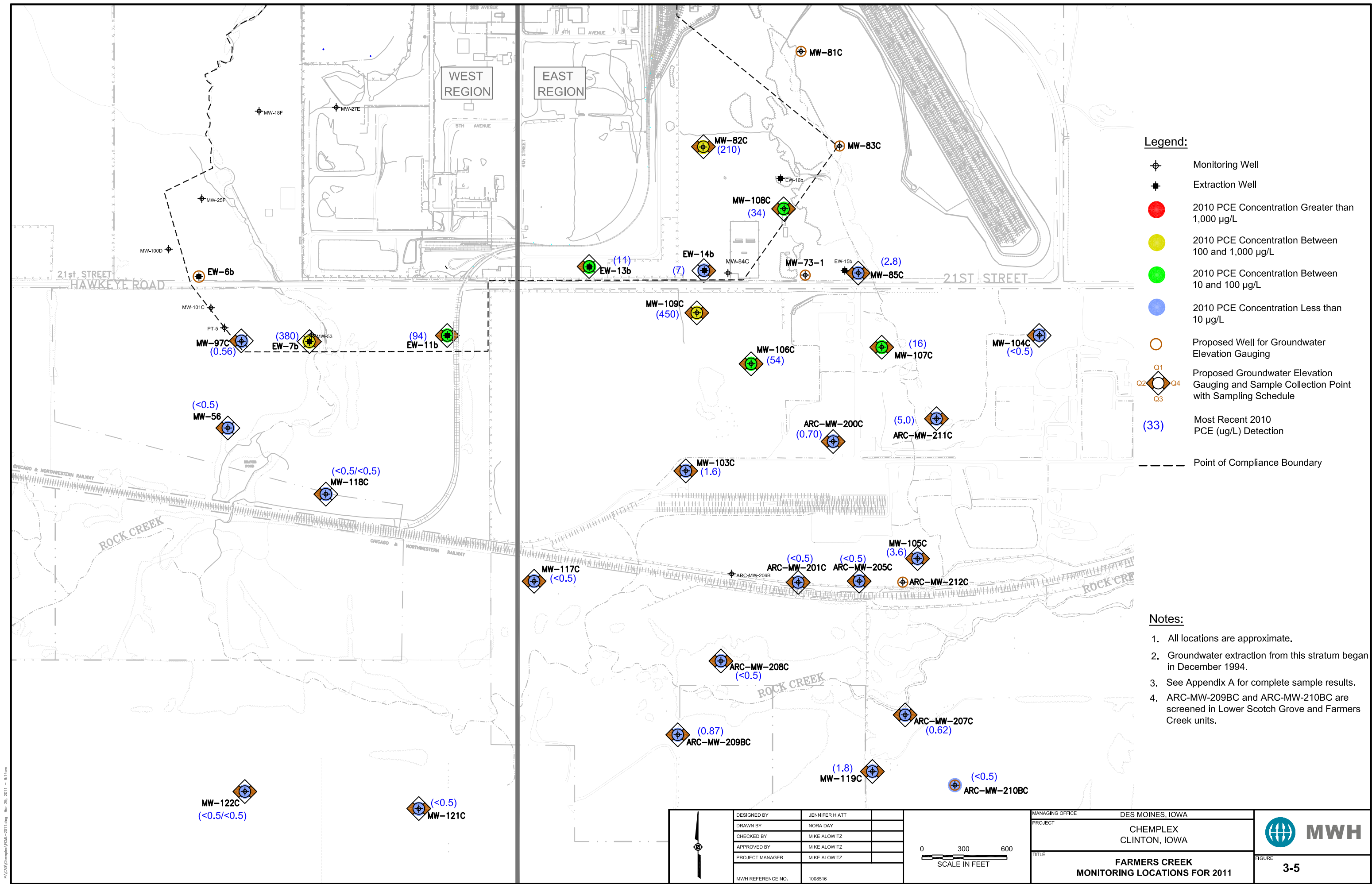
SG = Scotch Grove

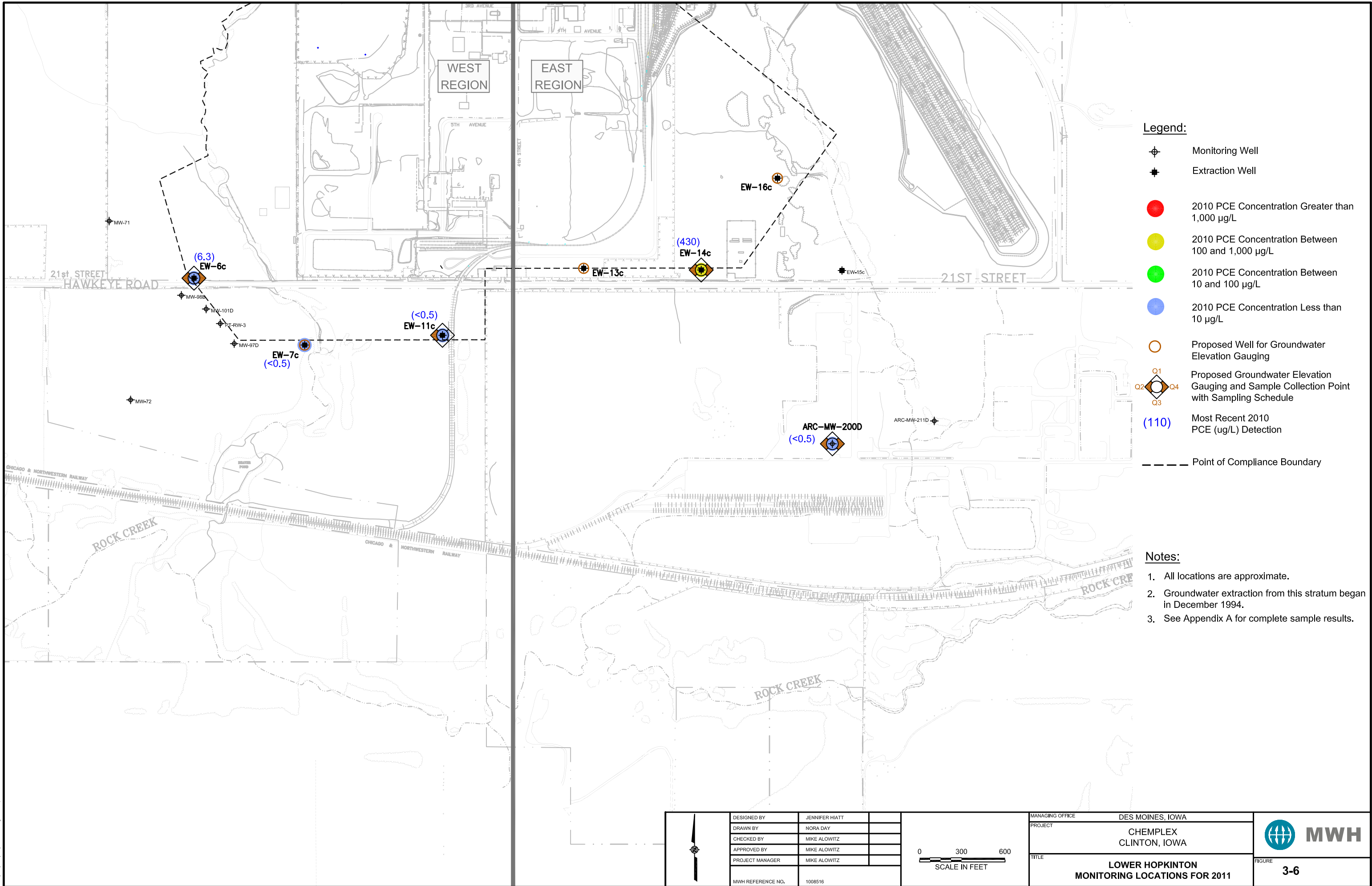
USG = Upper Scotch Grove

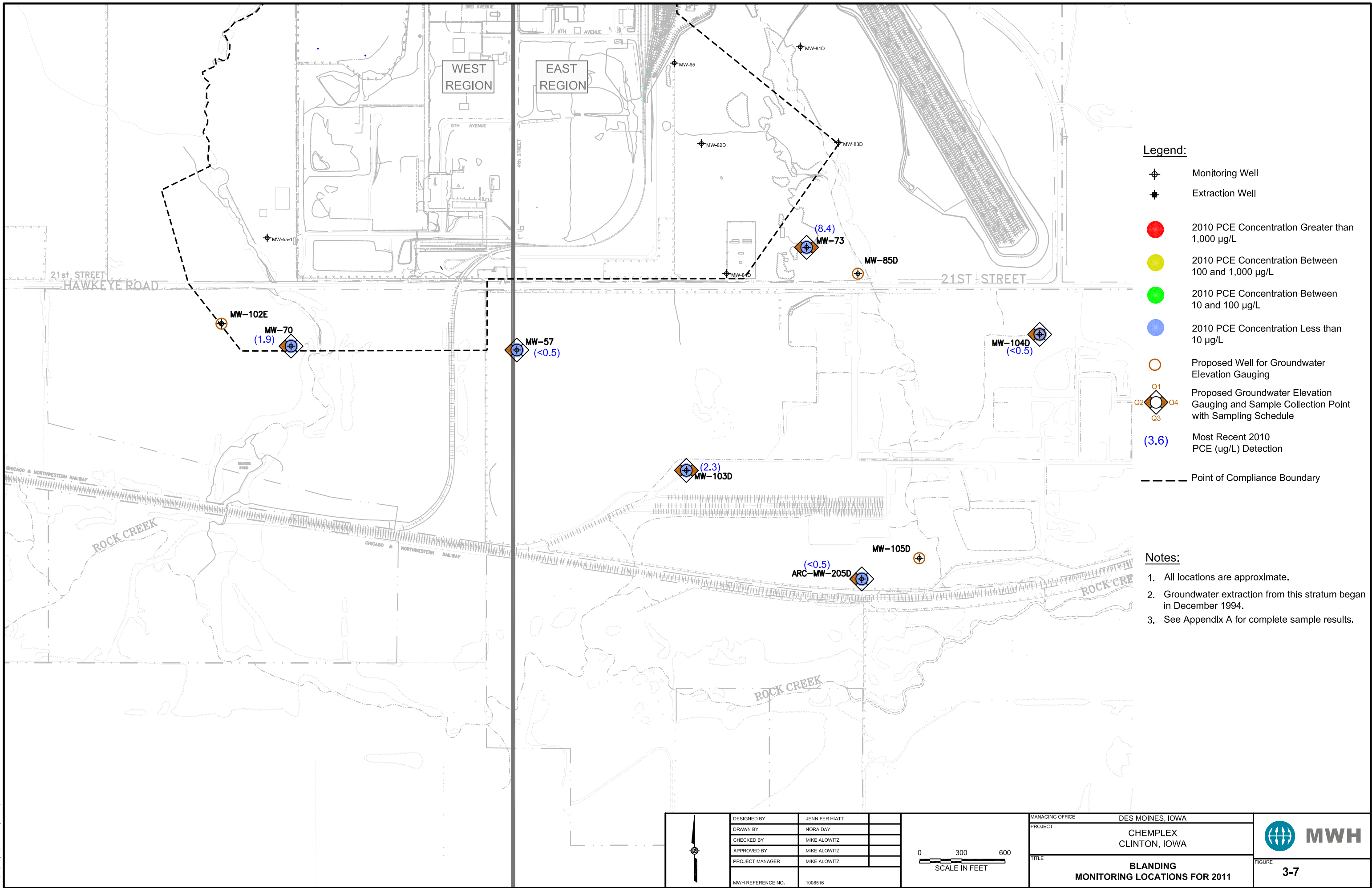
VOCs = Volatile organic compounds.











- Legend:**
- Monitoring Well
 - Extraction Well
 - 2010 PCE Concentration Greater than 1,000 µg/L
 - 2010 PCE Concentration Between 100 and 1,000 µg/L
 - 2010 PCE Concentration Between 10 and 100 µg/L
 - 2010 PCE Concentration Less than 10 µg/L
 - Proposed Well for Groundwater Elevation Gauging
 - Proposed Groundwater Elevation Gauging and Sample Collection Point with Sampling Schedule
 - Most Recent 2010 PCE (ug/L) Detection
 - Point of Compliance Boundary

- Notes:**
- All locations are approximate.
 - Groundwater extraction from this stratum began in December 1994.
 - See Appendix A for complete sample results.

DESIGNED BY	JENNIFER HIATT
DRAWN BY	NORA DAY
CHECKED BY	MIKE ALOWITZ
APPROVED BY	MIKE ALOWITZ
PROJECT MANAGER	MIKE ALOWITZ
MWH REFERENCE NO.	1008516



MANAGING OFFICE	DES MOINES, IOWA
PROJECT	CHEMPLEX CLINTON, IOWA
TITLE	BLANDING MONITORING LOCATIONS FOR 2011

FIGURE
3-7

APPENDIX C:

Technical Impracticability Evaluation Report, prepared by MWH Americas, Inc.,

dated February 2012

(Provided on Separate CD)

TECHNICAL IMPRACTICABILITY EVALUATION REPORT

FOR

OPERABLE UNIT NO. 1

**CHEMPLEX SITE
CLINTON, IOWA**

Prepared for

ACC/GCC

Project No. 1010756.0101

February 2012

Prepared by

**MWH
11153 Aurora Avenue
Des Moines, Iowa 50322
515-253-0830**

TECHNICAL IMPRACTICABILITY EVALUATION REPORT

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EXECUTIVE SUMMARY

ACC/GCC has prepared this Technical Impracticability Evaluation Report (TI Evaluation Report) for Operable Unit No. 1 (OU-1) for groundwater at the Chemplex Site (Site) located in Clinton, Iowa. Based on experience at other, similar sites, characteristics of the Site have the potential to severely limit the restoration potential of the underlying, chemically-impacted water-bearing zones. To assess restoration potential, ACC/GCC has conducted this site-specific evaluation of the practicability of groundwater restoration. This TI Evaluation Report is Appendix D to the *Updated Final Focused Feasibility Study* (Updated FFS) dated February 2012 (Erler & Kalinowski, Inc., 2012).

This TI Evaluation Report will show that it is technically impracticable from an engineering perspective to achieve existing groundwater cleanup goals; and summarize and evaluate site-specific data to establish an alternative, protective remedial strategy for site groundwater. This TI Evaluation Report has been prepared in accordance with the Environmental Protection Agency's (EPA's) *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration – Interim Final* (EPA, 1993).

Groundwater remediation is currently governed by the 1989 Record of Decision (ROD) (EPA, 1989) and EPA's 1991 Explanation of Significant Differences (ESD) (EPA, 1991b). In the 1989 ROD, EPA selected a pump-and-treat remedy to address site groundwater impacts. The ROD and ESD included numerical groundwater cleanup goals. The primary chemical of concern at the Site is tetrachloroethylene, also known as perchloroethylene or PCE. The Chemplex pump-and-treat groundwater recovery system was constructed in 1994 and continued operating until September 2008, when the system was put into standby service in accordance with EPA's approval.

The Chemplex OU-1 Feasibility Study, ROD, ESD, and Remedial Design were prepared in the late 1980s and early 1990s. Since that time, knowledge of groundwater behavior at the Site has greatly expanded, based on monitoring data from nearly 14 years of groundwater remediation. Extensive documentation is now also available regarding the potential of a variety of techniques to remediate groundwater at sites with similar stratigraphy and hydrogeology.

Multiple remediation phases have been completed at the Site, including groundwater extraction and treatment, placement of low permeability or vegetative covers over the Chemplex Landfill and other areas to reduce potential exposures to impacted soil, landfill gas extraction (LGE) from the Chemplex Landfill, and localized "hot spot" treatment using strong oxidants or supplemental electron donor. The Updated FFS and this TI Evaluation Report discuss the effectiveness of remediation efforts to date, and compare potential approaches to remediating site groundwater.

The Updated FFS and this TI Evaluation Report document that the groundwater recovery system did not effectively remove or contain PCE mass in groundwater due to the presence of fractured bedrock. As explained later in this TI Evaluation Report, PCE mass that had originally traveled to bedrock fractures in the form of dense, non-aqueous phase liquid (DNAPL), is believed to have migrated into dead-end fractures and surrounding rock pores. The DNAPL

residual is now back-diffusing into groundwater, and this back-diffusion will continue for many decades. The presence of fractures also precludes effective capture of PCE-containing groundwater due to preferential flow paths in the interlocking fractures that are difficult to intercept by extraction wells.

Despite the extended operation of the pump-and-treat system, in several site areas, particularly in the downgradient region southeast of the polyethylene plant now operated by Equistar Chemicals, the extent of PCE-containing groundwater above the cleanup goal has expanded in the vertical and horizontal dimension compared with prepumping conditions. This expansion is believed to have resulted from the complex fracture network present in the carbonate bedrock, which precludes the groundwater recovery system, even if enhanced with additional wells, from achieving complete, reliable, and effective hydraulic control of the plume. Based on the detailed analysis presented in the Updated FFS and this TI Evaluation Report, no available remedial approach, including innovative technologies, would achieve chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) for site groundwater at a reasonable cost and within a reasonable time frame.

It is not possible to estimate the restoration time frame with any certainty. It would likely take many decades or centuries for groundwater concentrations across the plume to reach chemical-specific ARARs. Several key factors present at the Site prevent compliance with chemical-specific ARARs for groundwater in a reasonable time frame:

- PCE, released in the form of free-phase DNAPL, has reached the underlying fractured bedrock. Much or most of this mass has likely migrated into rock pores surrounding these fractures. Back-diffusion of PCE from these rock pores will constitute a long-term source of dissolved chemicals to migrating groundwater.
- The complex fracture network, coupled with the large area and depth of chemically-impacted carbonate aquifers found at the Site, will not allow complete, reliable and effective groundwater capture or chemical destruction or removal. Long-term contaminant back-diffusion from the fractured bedrock matrix will severely limit groundwater restoration rates.

Site-specific data and evaluations presented in this TI Evaluation Report and Updated FFS show that it is technically impracticable, from an engineering perspective, to achieve chemical-specific ARARs for groundwater within the Site boundaries and portions of adjacent downgradient areas.

Based on site-specific information available, including this TI Evaluation Report, ACC/GCC requests that EPA waive certain chemical-specific ARARs within a defined area identified as the TI Zone. The proposed TI Zone encompasses areas of reported or likely residual and dissolved-phase PCE, PCE daughter products, and other Site chemicals of concern, including downgradient areas of fractured bedrock that are known to be chemically-impacted or that may become impacted. Within such areas it is technically impracticable to achieve such ARARs. ARARs would not be waived for areas outside the TI Zone.

The proposed TI Zone boundaries have been drawn with the following boundaries:

- The western TI Zone boundary is close to the boundary line of the Site, including a portion of the local stream known as the Western Unnamed Tributary. The boundary was drawn generally parallel to the 5 microgram per liter ($\mu\text{g/L}$) PCE concentration contour based on the most recent available groundwater monitoring data.
- The eastern TI Zone boundary encompasses the Eastern Unnamed Tributary, while excluding areas not known to contain elevated PCE concentrations. The boundary was drawn generally parallel to the 5 $\mu\text{g/L}$ PCE concentration contour based on the most recent available groundwater monitoring data.
- The northern (upgradient) boundary was drawn based on the inferred PCE plume boundary at a concentration of 5 $\mu\text{g/L}$, with 1992 PCE data used in areas where more recent data were not available.

The southern (downgradient) TI Zone boundary was drawn based on the existing 5 $\mu\text{g/L}$ PCE plume boundary, with an extension southward to allow for expected matrix diffusion.

The vertical dimension of the proposed TI Zone would extend from the shallowest occurrence of groundwater down to the top of the Maquoketa Formation, a vertical distance of about 200 to 250 feet. This thick layer of shale is a regional aquiclude. Water-bearing layers beneath the Maquoketa Shale would not be included within the TI Zone.

The TI Evaluation Report and Updated FFS summarize data that support an alternative remedial strategy for site groundwater. The proposed strategy more effectively protects human health and the environment. In addition to the extensive removal of chemical mass via groundwater and landfill gas extraction, and treatment that has already been accomplished, ACC/GCC proposes to implement a revised remedial strategy in lieu of the existing groundwater pump-and-treat system. This alternative approach is summarized below:

- The City of Camanche municipal water system has been expanded to designated downgradient residences located south of the Site to prevent potential future human exposure to impacted groundwater via consumption of drinking water. The majority of these residences, including those closest to the PCE and nitrogen plumes were connected to the municipal water supply in 2010.
- Potential future exposure will also be prevented or reduced through institutional controls, including: 1) environmental covenants restricting shallow potable water well construction in areas downgradient of the Site; 2) environmental covenants restricting on-site construction of shallow potable water wells; and 3) an ordinance promulgated in 2010 by the City of Camanche prohibiting new water wells and requiring connection of new water services to the municipal water system.
- When determined to be appropriate in consultation with EPA, localized PCE “hot spots” will be treated with a strong oxidant, such as permanganate, or a supplemental electron donor, such as vegetable oil, to reduce the potential for

significant chemical migration outside the TI Zone above groundwater cleanup goals. These technologies have been successfully pilot tested at the Site, with the test report included as Appendix A of the Updated FFS.

- Groundwater monitoring has been expanded to the area downgradient of the Site to evaluate groundwater chemical concentrations and to monitor natural attenuation processes.

The proposed implementation of this revised remedial approach, coupled with establishment of a TI Zone, is consistent with the Comprehensive Environmental Response, Compensation and Liability Act, as amended (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). In particular, Section 121 of CERCLA, 42 USC § 9621, provides that a remedial action not attaining ARARs may be selected if compliance with such requirements is technically impracticable from an engineering perspective and is waived by EPA. The regulations found in Title 40 of the Code of Federal Regulations (CFR) § 300.430(f)(1)(ii)(C)(3), and EPA's 1993 *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration – Interim Final* further address the use of TI waivers.

SECTION 1

INTRODUCTION AND BACKGROUND

This Technical Impracticability Evaluation Report (TI Evaluation Report) is a component of the *Updated Focused Feasibility Study* for Operable Unit No. 1 (OU-1) for groundwater at the Chemplex Site (Site) located in Clinton, Iowa. The *Updated Focused Feasibility Study* (Updated FFS) has been prepared separately by Erler & Kalinowski, Inc. (EKI) on behalf of ACC/GCC (EKI, 2012). Under the oversight of the Environmental Protection Agency (EPA), ACC/GCC previously completed a remedial investigation/feasibility study (RI/FS), Focused Feasibility Study, and remedial actions at the Site. Site activities are currently governed by the September 27, 1989 Record of Decision (ROD) (EPA, 1989) and the July 26, 1991 Explanation of Significant Differences (ESD) (EPA, 1991). The ROD and ESD include numerical groundwater cleanup goals intended to protect human health and the environment.

The restoration potential of the underlying aquifers is significantly limited by site characteristics; therefore, ACC/GCC has conducted this site-specific evaluation of the practicability of groundwater restoration within a reasonable time frame. Based on the detailed analysis presented in the Updated FFS, the earlier Final Focused Feasibility Study (FFFS) (EKI, 2007), and this TI Evaluation Report, none of the remedial alternatives retained for detailed evaluation, including those employing active remediation, are believed capable of achieving chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) for all site groundwater chemicals of concern (COCs) within a reasonable time frame. The Chemplex OU-1 Feasibility Study, ROD, ESD, and Remedial Design were prepared in the early 1990s. Since that time, knowledge of groundwater behavior at the Site has increased based on monitoring data from 14 years of groundwater extraction, and experience gained at other sites with stratigraphy and hydrogeology similar to the Site.

It is not possible to estimate the restoration time frame at the Site with any level of certainty; however, it would take many decades or centuries to attain chemical-specific ARARs for all COCs throughout the groundwater plume. Compliance with chemical-specific ARARs is precluded at the Site by hydrogeologic, geochemical, and contaminant-related factors, including a complex fractured bedrock aquifer and the inferred presence of dense nonaqueous phase liquid (DNAPL). This TI Evaluation Report has been prepared in accordance with the EPA's *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration – Interim Final* (EPA, 1993).

1.1 PURPOSE OF TECHNICAL IMPRACTICABILITY EVALUATION

This TI Evaluation Report will show that it is technically impracticable from an engineering perspective to achieve existing groundwater cleanup goals; and summarize and evaluate site-specific data that support an alternative, protective remedial strategy for site groundwater.

Multiple remediation efforts have been undertaken at the Site, including groundwater extraction and treatment, construction of low permeability or vegetative covers over the Chemplex Landfill and other areas to reduce potential contact, and landfill gas extraction (LGE) for mass removal

of volatile COCs from materials within the on-site Chemplex Landfill. The Updated FFS and TI Evaluation Report discuss the effectiveness of these efforts, and compare potential remedial alternatives to address site conditions. As demonstrated in the Updated FFS and this TI Evaluation Report, it is technically not practicable to achieve groundwater cleanup goals at a reasonable cost and in a reasonable time frame using available technologies.

1.2 SITE DESCRIPTION

The Site is located in Clinton County, Iowa in portions of Sections 19, 20, 29, and 30, of Township 81 North, Range 6 East. The Site, encompassing approximately 700 acres, is located approximately 1.5 miles northwest of the center of the City of Camanche and 5 miles west of the City of Clinton's downtown area, between U.S. Highway 30 and 21st Street (Figure 1-1). The Site is located within the city limits of Clinton and Camanche. This area is predominantly semirural, with agricultural fields and scattered residences. Until a westward extension of the Camanche municipal water system was completed in 2010 along 9th Avenue, these residences were served by private drinking water wells that were screened within the Overburden soil or shallow bedrock layers. The majority of designated residences located downgradient (south) of the Site are now connected to the municipal water supply.

Industrial land uses are also present in the area. The former Chemplex polyethylene manufacturing plant is currently operated by Equistar Chemicals, LP (Equistar). A former fertilizer manufacturing plant, previously known as Hawkeye Chemical, Arcadian Fertilizers, and then PCS Nitrogen, is located southeast of the Site. The PCS Nitrogen facility is currently owned by Cross Roads Land Development Corp, LLC (Crossroads). The Todtz Superfund Site is located approximately 1 mile to the south. The primary property owners in the Site vicinity are shown in Figure 1-2.

For discussion purposes, the Site is divided into two regions, the West Region and the East Region (Figure 1-1). In the West Region, the plume is believed to originate from the Chemplex Landfill, where spent PCE used to unclog plant process piping was disposed. The East Region plume, which is smaller than the West Plume, originates from an unidentified location within the polyethylene plant.

Two surface streams, the Eastern and Western Unnamed Tributaries, flow near the eastern and western boundaries of the Site. These two streams flow south, draining into Rock Creek. Rock Creek flows primarily west to east near the southern boundary of the former PCS Nitrogen property. About 1 ½ miles southeast of the Site, Rock Creek flows southward adjacent to a series of lakes that, in part, are the result of past quarrying operations. Rock Creek and the lakes eventually discharge to the Mississippi River, located approximately 2 miles south of the Site.

1.3 SITE HISTORY

The polyethylene plant began operation in 1968. It manufactures both low-density polyethylene (LDPE) and high-density polyethylene (HDPE). The plant includes several ethylene production areas, water and wastewater treatment plants, a landfill (the Chemplex Landfill) that is no longer

in use, and several other chemical and product storage tanks and loading areas. LDPE beads and HDPE flakes are shipped from the plant in trucks and railroad cars.

A major byproduct of the polyethylene manufacturing process is debutanized aromatic concentrate (DAC), a liquid that is approximately 40 to 50 percent benzene. This byproduct is stored in aboveground tanks inside the plant before shipment via railroad car or tanker truck.

The West Region of the Site includes the 7-acre Chemplex Landfill that was used for the disposal of various materials, including demolition debris and water treatment sludges. From about 1968 to 1978, tetrachloroethylene, also known as perchloroethylene or PCE, was used occasionally to clean clogged piping (ENSR, 1990). Spent PCE is believed to have been disposed in the Chemplex Landfill.

ACC/GCC operated the Chemplex facility from 1968 through 1984, after which it was sold to a series of owners. The polyethylene facility is currently operated by Equistar. ACC/GCC owns the land occupied by the Chemplex Landfill, as well as other properties to the southwest.

1.4 SITE ACTIVITY SUMMARY

Based on remedial investigations completed in the late 1980s through the early 1990s, groundwater in portions of the Site was found to have been impacted by PCE and its biodegradation daughter products; by benzene, toluene, ethylbenzene, and xylenes (BTEX); and by polynuclear aromatic hydrocarbons (PAHs). BTEX compounds are only found in groundwater in the western portion of the Site and are believed to be from the landfill area or historic DAC releases.

1.4.1 Description of Operable Unit No. 1 (OU-1)

The ROD for the First Operable Unit (OU-1 ROD) and subsequent project documents selected a groundwater pump-and-treat system to address site groundwater impacts (EPA, 1989). The initial ROD, issued in 1989, selected groundwater extraction and treatment for the Chemplex Landfill and the DAC Storage and Truck Loading Area. The presence of PCE in the form of DNAPL was not recognized at the time this initial ROD was issued.

After the presence of DNAPL was inferred from additional site monitoring data, the ROD was modified in 1991 by an Explanation of Significant Differences (ESD), which focused on containment of volatile organic compounds (VOCs) in groundwater instead of complete remediation.

The Chemplex groundwater recovery system was constructed in 1994. The system consists of 50 extraction wells that are screened at various depths in the soil Overburden and underlying bedrock layers. Extracted groundwater was treated by air stripping and aqueous-phase granular activated carbon adsorption. Treated groundwater was discharged to the Mississippi River through a permitted outfall shared with the neighboring Equistar polyethylene plant.

In 2004, EPA noted in its Second Five-Year Review (EPA, 2004) that the existing groundwater recovery and treatment system had not been able to fully contain groundwater VOCs within the Point of Compliance boundary, especially in the southeastern area of the Site. The report also states optimization through additional extraction wells is unlikely to be effective due to the impracticality of addressing DNAPL-related contamination in a fractured bedrock environment. In September 2008 with EPA's concurrence, the recovery system was put in stand-by mode to allow performance testing of an alternate remedy that did not include groundwater pump-and-treat.

1.4.2 Description of Operable Unit No. 2 (OU-2)

OU-2 remedial actions included constructing a low-permeability cover over the Chemplex Landfill and extracting landfill gases to reduce VOC mass remaining in the landfill material. Vegetative covers were also established in other areas with potential soil contamination within the Equistar polyethylene manufacturing facility. The ROD for OU-2 (EPA, 1993) states the Remedial Action Objectives for these measures were "to eliminate direct contact threats posed by the contaminated soils and wastes and reduce contaminant migration from soils and wastes to groundwater." EPA and the potentially responsible parties entered into a Consent Decree for OU-2 in 1995 (EPA, 1995).

The low-permeability cover and LGE system were constructed in 1997. The cover on the Chemplex Landfill is a multi-layer cap system. A low-permeability geomembrane consisting of 40-mil thick HDPE was placed over a grading layer of compacted soil to restrict infiltration of precipitation into the Chemplex Landfill. A geo-grid drainage layer was installed over the geomembrane to facilitate removal of infiltrated surface water. Clean, vegetated soil was placed over the drainage layer. Details of the cover are described in the Construction Completion Report prepared by Golder Associates (1998).

The LGE system operated from February 1998 to April 2003. The system consisted of 55 LGE wells, a collection system for floating product, and a catalytic oxidizer for treating the VOC-containing extracted vapor stream. As approved by EPA, the LGE system was permanently shut down once four years of cumulative operation was achieved for all active LGE wells. The rate of VOC recovery from the LGE system progressively decreased and, at the time the system was shut down, had reached low-rate, asymptotic conditions. Approximately 53,100 pounds of VOCs were removed by the LGE system, including approximately 32,700 pounds of the five designated Target Compounds (PCE and BTEX). ACC/GCC continues to maintain the Chemplex Landfill low permeability vegetative covers and Equistar maintains the vegetative covers within the Equistar facility.

1.5 EXISTING GROUNDWATER USE

Groundwater in the area is available from four aquifers: the unconsolidated Overburden soil, a series of Silurian dolomite bedrock zones, the Cambrian-Ordovician aquifer, and the Dresbach aquifer. The Overburden and Silurian aquifers are hydraulically connected. A low-permeability shale, called the Maquoketa Formation, and considered to be a regional aquiclude, separates the Silurian and Cambrian-Ordovician aquifers. Groundwater in the Cambrian-Ordovician aquifer is obtained mainly from the Jordan Sandstone. Additional confining beds separate the Cambrian-Ordovician aquifer from the Dresbach aquifer. Known water wells located around the Site are identified in Figure 1-3 and Table 1-1.

COCs from the Site have impacted the Overburden and the Silurian dolomite bedrock formations, but have not migrated to the deeper Cambrian-Ordovician and Dresbach zones. Process water used at the Equistar plant is extracted from dolomite and sandstone layers located below the Maquoketa Shale, well below the VOC-impacted bedrock at Chemplex. No groundwater from above the Maquoketa Shale is currently extracted or is anticipated to be used for drinking or industrial process uses in the Equistar plant area, as these shallower layers cannot produce a flowrate sufficient for most industrial process uses. Environmental covenants for the facility will prohibit the use of groundwater from above the Maquoketa Shale. Such environmental covenants are undergoing final review by EPA at the present time.

South of 21st Street, the former PCS Nitrogen fertilizer manufacturing plant has been demolished, except for the former product storage tanks and railroad yard. This property is zoned industrial and the current land owner may develop portions of this property for industrial uses. Similar to the practice at Equistar, industrial developments at the former PCS Nitrogen property would reportedly draw groundwater from the more-productive bedrock layers located below the Maquoketa Shale and not from the shallow zones of interest to the Chemplex remediation. Recorded environmental covenants prohibit the use of groundwater from above the Maquoketa Shale.

Other parcels downgradient (south) of the East and West Regions are in agricultural or semirural residential usage. The agricultural parcels do not use well water for irrigation. There are about two dozen residences in the area downgradient of the East and West Regions. Private wells at the majority of these residences were abandoned in 2010, following extension of the City of Camanche municipal water system westward along 9th Street and 31st Avenue. Figure 1-3 and Table 1-1 present the remaining known wells in the area.

1.6 RISK ASSESSMENT

ACC/GCC has assessed potential risks associated with exposure to chemical-containing groundwater for both human and ecological receptors.

1.6.1 Human Health Risk Assessment

A human health risk assessment is summarized in the Updated FFS and detailed in Section 3.6 of the FFS. The risk assessment was based on future steady-state groundwater VOC concentrations.

The risk assessment evaluated the potential receptors and potential exposure pathways summarized below:

- Adult Residents
 - Ingestion of groundwater extracted for domestic use.
 - Dermal contact with extracted groundwater while showering or bathing.
 - Inhalation of VOCs volatilizing to indoor air during domestic use of groundwater.
- Child Residents
 - Ingestion of groundwater extracted for domestic use.
 - Dermal contact with extracted groundwater while showering or bathing.
 - Inhalation of VOCs volatilizing to indoor air during domestic use of groundwater.
 - Dermal contact, ingestion, and inhalation of VOCs while wading in Rock Creek.

The exposure scenario of groundwater ingestion for domestic use presented an elevated risk. This hypothetical risk scenario has now been largely addressed by the connection of most of the designated downgradient private residences, including those closest to the Site, to the City of Camanche municipal water system. Groundwater at a residence west of and cross-gradient from the Site is routinely sampled and has not been impacted. The risk assessment found no other exposure scenarios that posed a significant hypothetical human health risk.

1.6.2 Ecological Risk

Based on the ecological risk evaluation described in Section 3.8 of the Updated FFFS, it is anticipated that groundwater VOC concentrations in Rock Creek, the Lower Rock Creek Wetlands, and the Mississippi River will comply with potentially-applicable surface water quality criteria. Present and projected VOC concentrations in these surface waters were compared with identified potentially-applicable ecological water quality criteria. Under all modeling scenarios, these conservatively-projected concentrations satisfied water quality criteria. To monitor compliance with these criteria, surface waters in Rock Creek, the West Tributary, and the East Tributary are routinely sampled as part of the Chemplex monitoring program.

1.7 REMEDIAL ACTION OBJECTIVES AND GROUNDWATER CLEANUP GOALS

Based on available site information and overall state of remediation knowledge at the time, EPA selected groundwater extraction and treatment in 1989 as the remedy for PCE and BTEX in site groundwater. The ROD for OU-1 (EPA, 1989) stated that the remedial action objectives (RAOs) for the Chemplex recovery system are “to mitigate the movement of contaminated ground water from the Site and to permanently treat, destroy, and dispose of contaminants found in these groundwater plumes.”

The behavior of chlorinated solvent DNAPL in a fractured rock environment and its significance as an obstacle to groundwater remediation were not understood at the time the 1989 ROD was prepared. After evaluating additional site information newly available during the early 1990s,

EPA modified the ROD in 1991 by issuing an ESD (EPA, 1991). EPA, recognizing the limited effectiveness of available technologies to remediate DNAPL in fractured bedrock, modified the RAOs to focus on containment of VOCs in groundwater, rather than their permanent removal or destruction as had been stated as a goal in the ROD. The ESD also established a Point of Compliance boundary, within which it was acknowledged that cleanup goals for groundwater would not be achieved. Non-compliant areas outside the Point of Compliance Boundary were called Areas of Attainment. The ESD called for ACC/GCC to operate its pump-and-treat system in an effort to attain cleanup goals within the Areas of Attainment.

The current and proposed groundwater cleanup goals, as discussed in Section 4.2 of the Updated FFS, are provided in Table 1-2.

SECTION 2

CONCEPTUAL SITE MODEL

2.1 SITE GEOLOGY

The stratigraphic layers of importance at the Site, from the ground surface downward, consist of 1) unconsolidated sediment (i.e., Overburden soil); 2) several fractured Silurian-era dolomite layers, consisting of the Scotch Grove Formation (subdivided into the Upper Scotch Grove and Lower Scotch Grove layers), the Hopkinton Formation (subdivided into the Picture Rock, Farmers Creek, and Lower Hopkinton layers), the Blanding Formation, and the Tete des Morts and Mosalem Formations; and 3) the Ordovician-era Maquoketa Formation shale layer.

2.1.1 Overburden

The Overburden at the Site consists of loess, glacial drift material, and older alluvial sediments. During the Quaternary age, advancing glaciers eroded most of these alluvial sediments. In place of the alluvium, loess and glacial drift were deposited that consist predominantly of mixed clay and silt with sand and gravel stringers. Remnants of the alluvial sediments can be found filling ancient stream channels and depressions carved in the bedrock at the base of the Overburden.

The alluvium, consisting of gravel, cobbles, or boulders, is referred to as the basal sand and gravel. The basal sand and gravel is present mainly in the southwestern area of the Site. The Overburden ranges in thickness from less than 1 foot along the Western Unnamed Tributary adjacent to the polyethylene plant to approximately 90 feet in areas south of 21st Street (JMM, 1992).

2.1.2 Silurian-Era Bedrock

Beneath the Overburden is a sequence of Silurian-era carbonate bedrock. The dolomitic, Silurian-era bedrock sequence at the Site has been categorized into three groups of geologic formations, namely the 1) Scotch Grove Formation, 2) Hopkinton Formation, and 3) Blanding, Tete des Morts, and Mosalem Formations (Figure 2-1).

2.1.2.1 Scotch Grove Formation. The top of the Scotch Grove Formation is encountered at an elevation of about 540 to 660 feet relative to the National Geodetic Vertical Datum (NGVD). The Scotch Grove Formation ranges in thickness from 19 to 140 feet across the Site. The formation is divided into upper and lower layers based upon the results of seismic refraction and electrical resistivity surveys (ENSR, 1992), which are geophysical methods of assessing bedrock conditions. Changes in the geophysical signature recorded by these surveys have been interpreted to reflect the boundary between rock that is weathered, considered to be the upper member of the formation, and rock that is not weathered, in the lower member. Rock cores obtained from borings completed at the Site confirm that much of the Upper Scotch Grove Formation is highly weathered and relatively porous (ENSR, 1989, 1992). The bedrock surface exposed at a nearby outcropping indicates a pattern of interlocking fractures.

2.1.2.2 Hopkinton Formation. The Hopkinton Formation lies below the Scotch Grove Formation. The top of the Hopkinton Formation is encountered at depths of approximately 90 to 150 feet below ground surface (bgs), equivalent to an elevation of 490 to 550 NGVD. The Hopkinton Formation, varying in thickness from 70 to 110 feet, is composed of the Picture Rock, Farmers Creek, and Lower Hopkinton layers.

The Picture Rock Member is a gray, fine-grained dolomite that ranges from 10 to 30 feet thick. The Picture Rock Member, which is less permeable than either the overlying Scotch Grove Formation or the underlying Farmers Creek Member, is considered to be an aquitard.

The top of the Farmers Creek Member is located approximately 110 to 180 feet bgs (460 to 520 feet NGVD) at the Site. The Farmers Creek Member is 15 to 20 feet thick and is extremely porous due to fossil molds and solution cavities and holes, called “vugs.” Fossil molds and solution cavities are formed when groundwater flows through fractures and widens them over time by dissolving the fossils and minerals from the surrounding bedrock. The presence of fossil molds and solution cavities makes the Farmers Creek Member regionally the most consistently groundwater-productive stratum in the Silurian-era bedrock sequence (Wahl and Bunker, 1986), although the weathered portions of the Scotch Grove are generally more productive at the Site.

The top of the Lower Hopkinton Member is encountered at depths of approximately 130 to 200 feet bgs (440 to 500 feet NGVD) at the Site. The Lower Hopkinton Member is 40 to 60 feet thick. Dolomite in the Lower Hopkinton Member is generally porous and contains cavities.

2.1.2.3 Blanding Formation. The Blanding Formation underlies the Hopkinton Formation. The top of the Blanding Formation is located approximately 190 to 250 feet bgs (400 to 450 feet NGVD). The Blanding Formation is typically 20 to 40 feet thick and contains dolomite with abundant chert nodules and seams. Locally, chert may make up as much as 50 percent of the Blanding Formation (JMM, 1992). The Blanding Formation is dense to slightly porous. This formation is the deepest layer reached by the Chemplex monitoring well network.

2.1.2.4 Tete des Morts and Mosalem Formations. The Tete des Morts and Mosalem Formations lie beneath the Blanding Formation. Because these formations are thin and relatively deep, they are typically not discussed in site documents. The top of the combined Tete des Morts/Mosalem Formation is encountered at depths of approximately 200 to 270 feet bgs (380 to 430 feet NGVD), with a combined thickness of about 10 feet. Dolomite in the Tete des Morts and Mosalem Formations contains chert nodules and shale seams, and is typically very dense.

2.1.3 Ordovician-Era Bedrock

The Brainard Shale of the Ordovician-era Maquoketa Formation underlies the Silurian bedrock (Wahl and Bunker, 1986). The Maquoketa Formation is a massive sequence of shale that has very low permeability and ranges in thickness from 114 to 275 feet (Bunker, et al., 1985). The massive, dense shales of the Maquoketa Formation have extremely low permeability and are considered a regional aquiclude.

2.2 SITE HYDROGEOLOGY

Groundwater occurs at the Site within both the Overburden and the underlying bedrock layers. In general, groundwater flows laterally from north to south at the Site in conformance with area topography, with higher horizontal gradients seen in the areas near the Eastern and Western Unnamed Tributaries.

2.2.1 Overburden Groundwater Flow

Groundwater is typically first encountered at depths of 1 to 8 feet bgs at the Site. Principal flow paths for Overburden groundwater are the sand and gravel stringers in the loess and glacial drifts, and the basal sand and gravel in the southwestern area of the Site. Groundwater movement in the Overburden is influenced by the Eastern and Western Unnamed Tributaries. Investigations have demonstrated that groundwater in the Overburden exfiltrates into these Unnamed Tributaries (ENSR, 1992), with groundwater providing much of the baseflow in these streams during dry periods.

Groundwater in the West Region of the Site generally flows to the southwest, and groundwater in the East Region flows to the southeast. Groundwater velocity in the Overburden under prepumping conditions has been estimated at 24 feet per year (ENSR, 1992).

Groundwater vertical hydraulic gradients within the Overburden are upward near the Western and Eastern Unnamed Tributaries, consistent with the findings that groundwater recharges these tributaries. Elsewhere at and near the Site, groundwater vertical hydraulic gradients within the Overburden are downward (James M. Montgomery [now MWH], 1992).

2.2.2 Bedrock Groundwater Flow

The bedrock water-bearing zones are usually confined, with the groundwater potentiometric surface typically situated within the Overburden. The Western and Eastern Unnamed Tributaries appear to affect groundwater flow in the shallower bedrock zones as well as in the Overburden (James M. Montgomery, 1992). Groundwater flow in the bedrock is skewed to the south near these tributaries. Groundwater velocity in the bedrock under prepumping conditions has been reported to vary from an estimated 1.5 feet per year (ft/yr) in the Picture Rock layer to 76 ft/yr in the Upper Scotch Grove layer (ENSR, 1992).

Recharge of Silurian-era bedrock in Iowa results primarily from precipitation that infiltrates through the Overburden (Horick, 1984). Downward groundwater flow through bedrock occurs at the Site given the average annual rainfall of 36 inches (ENSR, 1989) and the existence of naturally-downward vertical hydraulic gradients between the Overburden and bedrock throughout much of the Site (James M. Montgomery, 1992) plus recharge from upgradient areas.

Even though all formations in the Silurian-era bedrock sequence are hydraulically interconnected, downward VOC transport via groundwater is inhibited by the Picture Rock layer, which exhibits lower permeability than the other bedrock strata. The Chemplex Landfill, located along the eastern boundary of the Equistar polyethylene plant, is believed to be the source of PCE found in the West Region of the Site. PCE is the main COC at the Site. PCE

concentrations in groundwater in the Scotch Grove Formation, which overlies the Picture Rock, are greater than PCE concentrations in groundwater below the Picture Rock layer.

Downward vertical gradients have been measured in the Site's East Region. Such gradients, which appear to be natural, are measured in the East Region both across the Picture Rock layer and between the bedrock layers underlying the Picture Rock. In contrast, vertical gradients in the West Region bedrock are near-neutral.

2.2.3 Groundwater Pumping and Potentiometric Surface

Figures 3-2 and 3-3 of the Updated FFS show the estimated groundwater potentiometric surfaces in April 2008 for the Upper Scotch Grove Formation and Lower Scotch Grove Formation. These figures show significant influence at active extraction wells, with defined capture zones (the pump-and-treat system was still operating at the time data were collected). Figures 3-5 and 3-6 of the Updated FFS show the same units in May 2010, after pumping had been off-line for 20 months. The horizontal gradients flattened out, reducing groundwater velocities; and the former capture zones had returned to prepumping conditions.

2.3 RESIDUAL SOURCE MATERIALS AND RELEASE MECHANISMS

PCE disposed of as DNAPL is believed to have been the primary source of groundwater at the Site. The term DNAPL refers to liquids that are heavier than water and do not readily dissolve in water. The PCE is believed to have originally been released in the form of nearly-pure DNAPL after being used to unclog plant process piping. These primary source materials may have initially constituted a separate, drainable, DNAPL independent of the soil and bedrock matrix, but now are believed to have largely migrated into dead-end bedrock fractures and rock pores.

At this time, several decades after the original release, it is likely that most of the residual PCE mass has migrated into bedrock pores surrounding fractures. By the mechanism of back-diffusion of PCE mass from rock pores, the residual source material will be a long-term source of further releases to groundwater, for many decades or centuries.

2.4 CONTAMINANT FATE AND TRANSPORT

The predominant mechanisms of contaminant fate and transport at the Site are believed to consist of the following: precipitation that infiltrates unsaturated soil and dissolves contaminants, downward migration of dissolved contaminants to groundwater, downward and horizontal migration of source material in the form of DNAPL, dissolution of DNAPL into groundwater, and lateral and vertical migration of dissolved contaminants in the direction of groundwater flow.

2.4.1 Infiltration/Percolation and Downward Migration of Dissolved Contaminants

Percolation of precipitation and surface water through impacted vadose (unsaturated) zone soil can result in the dissolution and downward migration of dissolved contaminants through the soil column. The majority of the Site surface is permeable (covered with grass or gravel), which allows infiltration and percolation of precipitation. Historically, the DAC Storage and Truck Loading Area was not paved or otherwise protected from surface water infiltration, and

contamination of soil and groundwater occurred as a result of releases of DAC product. Subsequent paving has reduced the potential for surface water infiltration in this area. A low-permeability cover was installed over the Chemplex Landfill and other designated areas in 1997 to restrict infiltration of precipitation in this area. Areas covered with buildings and pavement limit surface water infiltration and percolation.

2.4.2 DNAPL Migration and Dissolution

After a release, DNAPL migrates through vadose zone soil along preferential pathways laterally and vertically, due to the force of gravity acting on this dense material. DNAPL will migrate along multiple pathways, both vertically and laterally, often in a dendritic (branched) pattern. The specific DNAPL migration pathways of DNAPL are governed by the bedding structure of the unconsolidated material (Kueper et al., 2003).

The DNAPL remains as residual contamination in pore spaces and fractures. The residual DNAPL can distribute in disconnected blobs and ganglia (thin branches) formed at the trailing end of a migrating DNAPL mass. Residual DNAPL acts as an ongoing secondary source of contamination through dissolution and volatilization. Water flow through residual DNAPL slowly dissolves and transports soluble contaminants.

If a sufficient volume of DNAPL is released, free-phase DNAPL will continue to migrate laterally and downward until intercepted by a low-permeability layer, such as low-permeability bedrock. At such a layer, DNAPL pools may form and the DNAPL may continue to migrate laterally along the surface of the low-permeability layer. Due to its density, low aqueous solubility, and high tendency to sorb to organic materials, DNAPL can exist as a separate, immiscible phase that will sink in groundwater. Soluble DNAPL constituents will then slowly partition into the aqueous phase when DNAPL is in physical contact with groundwater (EPA, 1991).

DNAPL can enter open bedrock fractures if the capillary entry pressure exceeds the fracture entry pressure (Lipson et al., 2005). It is likely that after DNAPL enters a fracture network, it continues its downward and lateral migration until the DNAPL source is dissipated into the fracture network and absorbed by the surrounding rock pores (Kueper et al., 2003). The dolomite bedrock underlying the Site and downgradient areas is extensively fractured and contains vugs and other rock pores.

Based on experience at this and other sites, the distribution of DNAPL or other residual PCE sources in the subsurface is impracticable to characterize. Although DNAPL has not been directly observed in site monitoring wells, historical site use and groundwater concentrations suggest the presence in the past of residual or free phase DNAPL. Spent PCE used for unclogging process pipes at the polyethylene plant was reportedly disposed in the Chemplex Landfill. This spent PCE would have been in the form of a nearly-pure DNAPL. Table 2 of Decision Chart 1 in *Estimating Potential for Occurrence of DNAPL at Superfund Sites* identifies “disposal of mixed chemical wastes in landfills” as a waste disposal practice with a high probability of causing DNAPL releases (EPA, 1992). According to Table 5 of Decision Chart 2 of the same document, groundwater concentrations such as those detected at the Site indicate the possible presence of DNAPL by meeting Condition 1, which states DNAPL-related contaminant concentrations are found to exceed 1 percent of the pure phase or effective

solubility (EPA, 1992). PCE's solubility in water at 25 degrees C is about 150 milligrams per liter (mg/L), such that 1 percent of that maximum solubility is 1.5 mg/L, or 1,500 micrograms per liter (µg/L).

PCE concentrations exceeding 10 percent of PCE's pure-phase solubility, detected in the past in the bedrock aquifer, indicate PCE in DNAPL form was likely present and penetrated the fractured bedrock formation immediately underlying the Chemplex Landfill. PCE has been detected in West Region groundwater at concentrations as high as 95,000 µg/L, equivalent to 63 percent of PCE's aqueous solubility, at monitoring well MW-17B and at 5,500 µg/L, or 4 percent of solubility, in the East Region at monitoring well MW-115A.

Based on historic site use and measured groundwater concentrations, PCE DNAPL likely entered the subsurface in the Chemplex Landfill area in the West Region. A possible smaller source, which could not be identified, may exist in the East Region of the Site. Site data indicate the DNAPL migrated vertically through the Overburden and entered fractures within the Scotch Grove Formation. PCE DNAPL was placed near, or directly on top of, the Scotch Grove bedrock layer, which was reportedly directly exposed in portions of the Chemplex Landfill. DNAPL migration likely continued laterally and vertically through the fractured bedrock, leaving a trail of residual DNAPL. The relatively low-permeability Picture Rock dolomite layer, considered to be an aquitard restricting groundwater flow, is believed to have trapped most of the downward-moving DNAPL within the upper and lower portions of the Scotch Grove Formation.

The difficulty in locating residual DNAPL is a major obstacle to source remediation at sites having chlorinated solvents in DNAPL form, including this site. There is no practicable and reliable means of identifying or locating residual DNAPL or other forms of residual PCE mass. Attempting to remediate DNAPL could promote mobilization of meta-stable residual material.

The presence of residual DNAPL in fractured bedrock or its migration into surrounding rock pores also eliminates the potential for reliable VOC plume remediation by controlling remaining source areas. Even if all residual DNAPL at the Site source areas could somehow be identified and completely destroyed, most of the remaining PCE mass is likely now located in rock pores. This remaining mass will continue to diffuse back out of the impacted fractured rock into migrating groundwater, with this process likely to continue for many decades or centuries.

2.4.3 Groundwater Pump and Treat

Groundwater flow through partially-interconnected horizontal and vertical fractures in the dolomite bedrock and the diffusion and back-diffusion of residual PCE mass are responsible for the continued lateral migration of dissolved-phase PCE despite the past operation of the pump-and-treat system. This back-diffusion is discussed in Section 2.4.4.

Reliable containment and effective remediation of contaminated groundwater in fractured rock is not possible for the following reasons noted by the National Research Council (1994):

- Predicting contaminant movement in fractured rock is extremely complex because contaminants will move along the line of least resistance, which is the

fracture and often in a direction that cannot be determined by conventional methods for hydrogeologic investigations. Because of the tendency of contaminants to move through the fractures to locations that are difficult to determine and access, remediation of fractured rock aquifers poses an extreme technical challenge.

- In general, coarse-grained unconsolidated media are easier to treat and monitor than fine-grained or highly-heterogeneous material. DNAPL contamination in clay and fractured bedrock is even more difficult. Complex hydrogeologic settings (e.g., tight soils, fractured bedrock, karst) represent significant technical challenges and increased costs for treatment design, implementation, and performance assessment; and the fundamental technical difficulties of cost-effectively treating DNAPL sources in complex settings remain a largely unresolved problem.

Ten years later, a review of DNAPL treatment technologies by the Interstate Technology and Regulatory Council (2004) indicated the technical challenges of remediating DNAPL in fractured bedrock remained.

Due to the inability of extraction to capture groundwater from the entirety of the bedrock fracture network, the Chemplex recovery system has not been able to effectively and reliably contain groundwater impacted by VOCs. Due to this fracturing and to ongoing back-diffusion from surrounding rock pores, the hydraulic capture of the Chemplex recovery system cannot be significantly improved and made reliable by constructing additional extraction wells. The specific bedrock fractures that would need to be intercepted or influenced by the groundwater recovery wells, in order to reliably control VOC migration in such fractured rock, cannot be identified or intercepted with currently-existing technologies.

2.4.4 Back Diffusion from the Aquifer Matrix

PCE and other COCs in the form of DNAPL or dissolved-phase chemicals will travel through rock fractures and diffuse into the surrounding rock pores. The COCs will then back-diffuse from these pores into migrating groundwater. This back diffusion acts as a continuing, long-term source of groundwater contamination. Groundwater restoration at DNAPL sites having fractured bedrock is limited by the slow but continuous rate of diffusion of contaminants out of the matrix (Parker, et. al., 1994). Back diffusion takes a much longer period of time to remove the COCs from the rock matrix than did the original travel of COC mass into the rock matrix (Lipson et al., 2005). This slow back diffusion of COCs from the fractured bedrock matrix severely limits groundwater restoration rates, even if the original DNAPL has fully dissipated.

The ramification of such diffusion for the Site is that significant PCE mass will persist along the former DNAPL migration pathways long after the blobs and drops of residual DNAPL have largely disappeared. PCE will then back-diffuse out of the impacted clay, silt, and bedrock into migrating groundwater. As an example, Reynolds and Kueper (2002) modeled the migration of PCE DNAPL through a single fracture in a clay aquitard. They found that while the residual DNAPL disappeared in about 21 weeks, PCE in groundwater, at concentrations exceeding the

maximum contaminant level (MCL) for drinking water, was predicted to persist for over 1,200 years due to this back diffusion process.

This observed mass transfer limitation means that long-term removal of PCE mass will not be controlled by how fast groundwater is pumped, but instead by the rate at which PCE back-diffuses from the impacted silt, clay, and dolomite. Thus, additional groundwater extraction would not appreciably accelerate the time frame for site remediation by mass removal.

Dissolution of DNAPL-derived contaminants is believed to represent the primary source of dissolved contamination into the Site groundwater. The remediation time frame in the fractured bedrock aquifer zones will be lengthy, likely measured in decades or centuries, due to the complex fracture networks and the effects of long-term back diffusion of COCs out of the bedrock matrix.

2.5 CONTAMINANT DEGRADATION

The presence of contaminant transformation products and the evaluation of concentration trends indicate that a degree of contaminant degradation is occurring.

2.5.1 Biological Transformation

Biological transformation of chlorinated VOCs and BTEX by indigenous microorganisms, such as bacteria and fungi, can occur. Biodegradation is limited by COC bioavailability because microbial degradation acts on contaminant mass in the dissolved phase.

2.5.1.1 Chlorinated VOCs. Typically, only chlorinated VOCs with one or two chlorine atoms, such as cis-1,2-dichloroethylene (cis-1,2-DCE) and vinyl chloride (VC), can be directly oxidized by microorganisms under aerobic conditions. This subset of chlorinated VOCs can also be oxidized cometabolically (e.g., they can be metabolically processed in tandem with the metabolism of other compounds) under aerobic conditions. Trichloroethylene (TCE), a biological degradation product of PCE, has been observed to be cometabolically oxidized under aerobic conditions.

PCE does not degrade appreciably under aerobic conditions (EPA, 2000). Instead, PCE is typically degraded under anaerobic (non-oxygen) conditions through the process of reductive dechlorination by microorganisms. Reductive dechlorination results in the step-by-step biological degradation of PCE to TCE, TCE to cis-DCE, cis-DCE to VC, VC to nontoxic ethene, and finally to ethane. Based on research literature, trans-1,2-DCE and 1,1-DCE can also be formed. Requirements for reductive dechlorination include a sufficient population of bacteria that can use PCE and its daughter products as electron acceptors, similarly to how plants and animals use oxygen. Also needed are an adequate bacterial energy supply, called electron donor, and anaerobic, reducing (non-oxidizing) conditions.

2.5.1.2 BTEX. Numerous researchers have demonstrated BTEX compounds can be mineralized (oxidized to inorganic products) by both aerobic and anaerobic biodegradation; however, where BTEX concentrations are high, the bulk of BTEX degradation occurs under

anaerobic conditions, typically accompanied by sulfate reduction or methanogenesis (Barden, 2002a). While the aerobic pathways are expected to proceed more rapidly, without the active addition of oxygen in the aquifer oxygen is quickly depleted, causing conditions to become anaerobic.

2.5.1.3 PAHs. Although PAHs can be biodegraded under both aerobic and anaerobic conditions, the rate of biodegradation of PAHs is variable, depending on factors such as bioavailability and long-term exposure to and adaptation by microbes (Barden, 2002b). Sorption to organics in soil and bedrock is the dominant natural attenuation process for PAHs, which are typically only poorly mobile in groundwater.

2.5.2 Reductive Dechlorination Investigation

An investigation of chlorinated VOC degradation through reductive dechlorination was conducted at the Site in 1997 and 1998 and documented in the *Natural Attenuation Investigation: Summary of August 1997 In-Situ Groundwater Sampling* report (EKL, 1998), included as Appendix A in the FFFS. The findings of this investigation are summarized in the following paragraphs. The investigation findings were also presented in a meeting with EPA, Region 7 and with John Wilson of EPA's Ada, Oklahoma laboratory.

Site COC and geochemical data indicate PCE degradation through reductive dechlorination is occurring in several areas of the Site. The presence of sequential PCE transformation products (TCE, DCE, VC, ethene, and ethane) in site groundwater indicates PCE degradation is occurring through the reductive dechlorination pathway in both the West and East Regions. The detection of ethane and ethene indicates the complete dechlorination of PCE to nontoxic terminal products in certain site areas and bedrock layers.

Reductive dechlorination of PCE requires a sufficient supply of electron donor energy supply and suitable reduction-oxidation (redox) conditions. The supply of electron donor can be either naturally-occurring or placed there by human activity. These factors determine the pattern of PCE degradation occurring on site. The evaluation indicated strong evidence for biodegradation of PCE in the West Region and limited evidence in the East Region. The reason for greater biodegradation in the West Region is the presence of a carbon source (electron donor), such as BTEX compounds to support biodegradation of PCE and its daughter products. These carbon sources include other materials placed in the Landfill and DAC from prior releases. These other compounds are not found in appreciable amounts in the East Region.

2.5.3 Effect of Groundwater Extraction

When the groundwater pump-and-treat system was active, groundwater elevations were measured at least quarterly. Potentiometric surfaces were modeled and evaluated. Groundwater capture zones developed around extraction wells and increasing downward gradients were observed. The size of capture zones varied with local geology.

While the groundwater extraction system removed dissolved-phase COC mass from site groundwater, it also disturbed the lateral and vertical groundwater flow. As a result, groundwater extraction likely hindered the intrinsic anaerobic reductive dechlorination of the

chlorinated VOCs by introducing oxygenated groundwater into the plume areas—this introduction can occur because oxygenated water from outside the plume is drawn into the groundwater extraction wells. Dissolved oxygen (DO) concentrations less than 0.5 mg/L are generally required for anaerobic reductive dechlorination to occur (Wiedemeier et al., 1999), either in groundwater or within microenvironments within the bedrock matrix. Thus, introduction of oxygen-containing water from outside the plume could raise the DO concentration to levels inhibiting anaerobic activity.

Cessation of pumping flattened the horizontal groundwater gradients in the zones where extraction was previously conducted, serving to reduce groundwater velocities and thus increase groundwater residence time, allowing more time for biodegradation to occur. The Chemplex groundwater recovery system likely slowed the prepumping rate of reductive dechlorination by disrupting groundwater flow patterns and by introducing oxygenated water into the plume areas.

2.5.4 Effect of Downgradient Off-Site Nitrate Plume

The former PCS Nitrogen fertilizer manufacturing plant is located downgradient of the southeast site boundary (Figure 1-1). Past releases of nitrogenous compounds have resulted in increased nitrate concentrations in the Scotch Grove, Farmers Creek, and Lower Hopkinton layers in this area. Ammonia nitrogen and urea, other nitrogenous compounds, are also present.

The presence of nitrate could inhibit reductive dechlorination of PCE and TCE by providing competing electron acceptor; that is, bacteria that use nitrate as an electron acceptor will typically out-compete bacteria that use PCE or TCE. Therefore, if the chlorinated VOC plume from the East Region migrates into the nitrate-containing area, the rate of PCE and TCE biodegradation could decrease.

SECTION 3

ANALYSIS OF COMPLETED REMEDIAL ACTIONS

Remedial actions have been implemented at the Site to address COCs in groundwater (OU-1) and soil (OU-2). A summary of these remedial actions and their performance is presented in this section.

3.1 OU-1

Based on available site data, EPA selected groundwater extraction and treatment as the remedy for PCE and DAC in site groundwater in the Chemplex Landfill, and DAC Storage and Truck Loading Area, as set forth in the OU-1 ROD (EPA, 1989a). The OU-1 ROD stated the Remedial Action Objectives (RAOs) for site groundwater extraction and treatment system were “to mitigate the movement of contaminated groundwater from this site and to permanently treat, destroy, and dispose of contaminants found in these groundwater plumes.” Given available site information and the state of remedial practice at the time, the presence of PCE in the form of DNAPL was not recognized at the time the OU-1 ROD was issued.

After the presence of DNAPL was inferred from site monitoring data, EPA modified the ROD in 1991 by an ESD (EPA, 1991). In view of the limited effectiveness of available or prospective technologies to remediate DNAPL in a fractured bedrock environment, EPA’s ESD modified the RAOs to focus on containment, rather than complete removal, of VOCs in groundwater.

In an April 9, 2008 letter (EPA, 2008), EPA indicated a revised remedy may be appropriate if more data in support of a revised remedy were compiled. EPA’s April 2008 letter provided criteria for a performance test of a potential revised groundwater remedy emphasizing exposure control instead of continued pump-and-treat. These criteria were listed in the letter’s Statement of Additional Work (SOAW). In September 2008, ACC/GCC began the Performance Test in accordance with the SOAW. Components of this Performance Test included: 1) a complete shutdown of groundwater extraction and placement of the recovery and treatment system into stand-by mode, 2) expansion of the Site monitoring well system to better cover downgradient areas, 3) extension of the City of Camanche municipal water system to downgradient residents, and 4) pilot-scale “hot spot” treatment of localized elevated PCE concentrations. As of late 2010, the water main extension was complete, with private wells permanently abandoned for those residences electing to connect to the municipal water system. Results of the Hot Spot Pilot Study are detailed in the *Hot Spot Pilot Test Evaluation Report* (MWH, 2010), included as Appendix A to the Updated FFS.

3.1.1 Description

The Chemplex groundwater extraction and treatment system was constructed in 1994. The system operated until September 2008 when, with EPA approval, it was put into standby mode for the Performance Test. The groundwater recovery system consists of 50 extraction wells screened at various depths in the soil Overburden and underlying bedrock layers. Groundwater was extracted at flow rates ranging from approximately 1 to 20 gallons per minute per well. System wide, the flow rate averaged over 12 million gallons per month. After treatment,

extracted groundwater was discharged to the Mississippi River through a permitted outfall shared with the neighboring Equistar polyethylene plant.

The extraction wells required cleaning at least annually for biofouling control to maintain desired extraction flow rates. Biological fouling, typically in the form of bacterial slime, necessitated these aggressive well rehabilitation measures. Inorganic deposits were also found. Well rehabilitation included the use of acids to clean the well screens, which, although effective, likely would shorten well life by dissolving the surrounding dolomite formation rock. One former extraction well, DAC-2, was taken out of service, likely due to failure of the well pack caused by erosion of surrounding formation material by strong acids used for cleaning.

3.1.2 Performance

Nearly 28,000 pounds of VOCs were removed by extraction of site groundwater from 1994 through September 2008. Of the VOC mass extracted by the system, 85 to 90 percent is estimated to have originated from the West Region plume, with the remaining 10 to 15 percent of the extracted VOC mass originating from East Region groundwater.

As illustrated in Figure 3-1 and Table 3-1, the rate of VOC mass removal progressively declined since groundwater recovery system startup in 1994, reaching an asymptotic level of approximately 2 pounds per day. This decline suggests groundwater extraction removed the more-concentrated dissolved-phase COC concentrations available from preferential, easier-to-extract pathways (sand and gravel areas in the Overburden and the larger bedrock fractures). By the time of the September 2008 provisional shutdown, the Site groundwater extraction and treatment system was likely limited to removing COCs back-diffusing out of the bedrock matrix into groundwater—at that point, the COC mass removal rate was governed by the COC diffusion rate.

After 14 years of groundwater extraction, cleanup goals could not be achieved in any portion of the non-compliant Attainment Areas outside the Point of Compliance boundary. Analyses performed in 2007 and 2008, presented in detail in the FFFS and Updated FFS, concluded that 1) a significant portion of the PCE in groundwater, including in the downgradient Areas of Attainment, could not be recovered by the groundwater extraction system; and 2) since recovery system startup, the horizontal extent of the West Region and East Region plumes had generally not diminished, with PCE mass in the lower stratigraphic layers actually increasing in places. Compared with prepumping conditions in 1992, the extent of PCE has advanced further downgradient since the pump-and-treat system came online, based on data collected in 2008, while the groundwater extraction system was still operating, and in 2010, during the Performance Test. This situation was particularly seen in the area southeast of the current Point of Compliance boundary (Figure 3-2).

ACC/GCC suspended active extraction of groundwater from the Lower Hopkinton layer in 1999 and the Farmers Creek stratum in 2005 with EPA's approval in order to avoid increasing the naturally-downward vertical gradients that can pull contaminant mass to these lower layers. Even after the suspension of extraction from the Farmers Creek extraction wells, the portion of the groundwater extraction system remaining online was unable to reverse the

naturally-downward vertical gradients in certain site areas that can transport PCE mass downward into lower zones.

3.1.3 Role of Groundwater Recovery and Treatment

Groundwater VOC concentrations are below or near MCLs in the Area of Attainment in the West Region downgradient of the Point of Compliance boundary. Operation of the groundwater recovery system does not appear to be the primary factor enabling this progress toward achievement of cleanup goals. As discussed above in Section 2.5.2 the occurrence of intrinsic biodegradation of chlorinated VOCs has been demonstrated on site. Based on groundwater VOC concentrations measured prior to starting groundwater extraction and treatment, and the demonstrated presence of intrinsic reductive dechlorination, continued operation of the groundwater extraction and treatment system does not appear necessary to contain VOCs in the West Region of the Site as discussed in Section 2.5.2 and in Appendix A of the 2007 FFS.

In the East Region of the Site, the groundwater extraction and treatment system has not been able to fully contain VOCs in groundwater. PCE groundwater concentrations above the MCL have been measured in the Upper and Lower Scotch Grove, Farmers Creek, and Lower Hopkinton layers beyond the Point of Compliance boundary in the East Region. The VOCs are likely eluding capture by migrating through bedrock fractures not directly intercepted by the extraction wells and by replenishment into groundwater by ongoing back-diffusion from rock pores.

Based on groundwater modeling evaluations, the hydraulic capture of the Chemplex recovery system cannot be significantly improved by constructing additional extraction wells or extracting groundwater at a greater flow rate. The specific bedrock fractures that must be intercepted by the groundwater recovery wells to reliably and effectively control the migration of VOCs in groundwater cannot be predicted or identified and cannot be reliably intercepted. Complete and reliable containment and remediation of contaminated groundwater in fractured rock is not possible for the reasons described in Section 2.4.

The inability of the Chemplex recovery system to effectively and reliably contain chlorinated VOCs migrating in groundwater in fractured bedrock in the East Region has no material effect on use of downgradient groundwater as a potable water supply. Chlorinated VOCs dissolved in groundwater are flowing through bedrock toward significant nitrate-nitrogen, ammonia-nitrogen, and urea contamination below the former PCS Nitrogen fertilizer manufacturing plant, as shown in Figure 3-2. As a result of these high and persistent levels of nitrogenous compounds, it is doubtful that groundwater within the Silurian dolomites in this area will ever be available for potable or other beneficial uses. This impact by nitrogenous compounds will likely persist for many decades or centuries.

3.1.4 Extraction System Stand-By Operation

The groundwater pump-and-treat system was placed in stand-by mode in September 2008 to assess groundwater conditions in a non-pumping environment as part of the EPA-approved Performance Test of the “Exposure Control” alternative remedy. PCE concentrations in wells

sampled during the Performance Test are shown in Figures 3-8 through 3-13 of the Updated FFS (EKI, 2012).

These figures show that 66 out of the 72 wells sampled during both 2008 and 2010 had PCE concentrations in 2010 that were of the same order-of-magnitude as they were prior to start of the Performance Test. Three wells, including two that were part of the hot spot treatment pilot test, showed order-of-magnitude PCE decreases and three wells showed order-of-magnitude PCE increases. Based on these monitoring results, the lateral extent of the PCE plume has remained stable during the Performance Test.

3.2 OU-2

The OU-2 ROD was issued in 1993. The OU-2 remedial actions address threats posed by contaminated soils and wastes at the Site, which without remedial action could act as sources of groundwater contamination and potentially allow direct exposure to hazardous substances. The RAOs for OU-2 are “reduction of carcinogenic risk to on-site workers from direct dermal and inhalation exposure to soils to a risk level of approximately 1×10^{-6} or less” and “reduction of migration of contaminants into groundwater to the maximum extent practicable, consistent with the OU-1 groundwater remedy” (EPA, 1993). EPA and the Potentially Responsible Parties (PRPs) entered into a Consent Decree for OU-2 in 1995 (EPA, 1995).

3.2.1 Description

The major components of the OU-2 selected remedy are: extraction of VOC-containing gases from material in the Chemplex Landfill; groundwater suppression during gas extraction to maximize the available vadose (unsaturated) zone; multi-layer capping of the Chemplex Landfill; and capping or establishment of vegetative covers in other locations within the polyethylene plant; maintenance of the cap and cover systems; and application of institutional controls.

The low-permeability covers and LGE system were constructed in 1997 (Golder Associates, 1998). The LGE system operated from February 1998 to April 2003. The system consisted of 55 LGE wells, a collection system for light nonaqueous phase liquid (LNAPL), and a catalytic oxidizer for treating the VOC-containing vapor stream from the LGE wells. The LGE system was permanently shut down once the OU-2 Consent Decree performance standard of four years of cumulative operation was achieved for each active LGE well. ACC/GCC and Equistar continue to maintain the low permeability and vegetative covers.

3.2.2 Performance

Based on vapor flowrates and sample analyses, approximately 53,100 pounds of VOCs, primarily BTEX, pentanes, hexanes, and heptanes, were removed by the LGE system (Table 3-2). Approximately 32,700 pounds of this recovered mass consisted of PCE and BTEX compounds, which were the five Target Compounds designated in the OU-2 ROD. The LGE system also recovered approximately 2,730 gallons of LNAPL or water- LNAPL mixture, which comprised approximately 1.44 pounds of Target Compounds, 2.69 pounds of total VOCs, and 7,313 pounds of total hydrocarbons.

VOC recovery from the LGE system decreased over time and had reached a low, asymptotic rate at the time of system shutdown in 2003 (Figure 3-3). Figure 3-3 shows the rate of Target Compound mass removed in vapor from the LGE wells declined from approximately 50 pounds per day in 1998, reaching a level of approximately 4.3 pounds per day in 2003. The asymptotic recovery rate indicates the bulk of the VOC mass that could feasibly be extracted from the Chemplex Landfill had been removed by 2000. PCE comprised approximately 9 percent, or 4,500 pounds, of the total VOC mass removed by the LGE system.

SECTION 4

POTENTIAL REMEDIAL STRATEGIES

Section 4.7 of the Updated FFS describes three alternative groundwater remedies. As discussed in Section 4.4.4 of the TI Guidance (EPA, 1993), remediation of contaminant sources is critical to the success of aquifer restoration. Continued chemical releases from source materials to groundwater will greatly reduce the effectiveness of available or prospective aquifer restoration technologies.

Residual DNAPL can act as a long-term source of contaminants to groundwater. EPA recognizes that delineation of the extent of DNAPL is difficult at fractured rock sites (EPA, 1993) and once in the subsurface it is impossible to recover all of the trapped DNAPL (EPA, 1992). Furthermore, the groundwater restoration rate at DNAPL sites in fractured bedrock is further limited by the steady back-diffusion of entrained contaminants out of fractures and rock pores (Parker, et. al., 1994). All of these characteristics occur at the Site, making groundwater restoration technically impracticable.

4.1 REMEDY ALTERNATIVES

The following remedial strategies were evaluated in the FFS and Updated FFS:

- Under Alternative 1, “No Further Action,” the groundwater recovery and treatment system would be permanently shut down and no further action would be undertaken beyond system demolition.
- For Alternative 2, “Pump-and-Treat Remedy,” the Chemplex groundwater remediation system would be restarted and operate in a configuration similar to that existing before the start of the Performance Test.
- Under Alternative 3, “Enhanced Exposure Control,” the goal is to prevent potential human and ecological exposure to Chemplex COCs. In addition to the water main extension completed in 2010, other aspects of this remedy include hot spot treatment of locally-elevated PCE concentrations, an enhanced groundwater monitoring network, and institutional controls. A TI waiver would be obtained.

An analysis of these alternatives is presented in the Updated FFS. Due to known physical limitations of DNAPL remediation in a fractured bedrock environment, none of the potential remedial strategies or any available or prospective technologies are capable of restoring groundwater to achieve cleanup goals within a reasonable time frame. Based on these site-specific conditions and on experience at similar sites, Alternative 3 – Enhanced Exposure Control is the recommended alternative for the Site.

4.2 ENHANCED EXPOSURE CONTROL (ALTERNATIVE 3)

The Enhanced Exposure Control alternative reduces risk to potential human and ecological receptors by limiting exposure to potentially impacted groundwater and surface water. Alternative 3 is protective of human health by providing a municipal water source to downgradient residents for domestic use, thereby preventing future exposure to potentially-contaminated groundwater. The extension of the City of Camanche municipal water system and connection of the majority of downgradient residences were completed in 2010 during the Performance Test. Additional protection of human health and the environment would be provided by naturally-occurring attenuation, permanganate or electron donor injection, and a program of institutional controls and monitoring.

4.2.1 Institutional Controls

Institutional controls for the Site include proprietary controls in the form of environmental covenants, as provided under Iowa's Uniform Environmental Covenants Act. Environmental covenants restrict the use of groundwater underlying the Site and adjacent downgradient properties. Under such environmental covenants, access is granted to conduct remedial action, monitor existing groundwater monitoring wells, and construct new monitoring wells. Access would also be granted to EPA and the State of Iowa to verify compliance with groundwater use restrictions, conduct sampling, and monitor remedial action performance.

Current and proposed institutional controls to limit potential exposure to groundwater include:

- An ordinance enacted by the City of Camanche that prohibits new private water supply wells in the area downgradient of the Site and requiring connection to the public water system for future construction;
- Environmental covenants on certain properties, including the Equistar property, the Cross Roads Property (i.e., the former PCS Nitrogen property), the Chemplex Landfill property, and the other ACC/GCC-owned property that:
 - Prohibit the construction of wells screened above the Maquoketa Shale layer for human consumption, livestock watering, or agricultural use.
 - Require all new wells constructed through the Maquoketa Shale formation and screened within underlying layers be sealed during construction and operation to the satisfaction of the Iowa Department of Natural Resources (IDNR) and EPA.
 - Require the written permission of IDNR and EPA prior to abandoning or removing a well from the Site.
 - Prohibit residential use of the property.
 - Prohibit groundwater extraction from dewatering wells or sumps, as well as any activity that may interfere with groundwater monitoring,

groundwater extraction and treatment, or any other remedial action required by governmental authority.

- Grant access to EPA, IDNR, ACC/GCC, and their authorized contractors to conduct monitoring and other activities required by EPA or IDNR.

As part of the Performance Test of Alternative 3, all of the above institutional controls have now been implemented, with the exception of the Equistar environmental covenant that is in final EPA review.

4.2.2 Active Treatment and Engineering Controls

In an effort to address known, localized PCE “hot spots,” a strong oxidant such as permanganate or an electron donor such as vegetable oil would be applied to identified hot spots of elevated PCE concentrations. Details of such applications would be furnished in separate work plans. Successful pilot testing of these technologies was conducted during the Performance Test.

If COCs are detected in surface water at levels of concern, response actions may include installation of fencing to physically restrict access or construction of baffles to improve aeration and volatilization.

4.2.3 Compliance with Chemical-Specific ARARs

This alternative would comply with RAOs. As downgradient residences have been connected by ACC/GCC to the municipal water system, there are currently no completed downgradient exposure pathways to this potentially contaminated groundwater for the residences connected to the water system. Future residences would also be connected to the municipal water system, in accordance with ordinance requirements. Therefore, it is not expected that there would be any completed pathways in the future. Certain chemical-specific ARARs, including certain drinking water MCLs, would not be achieved within a designated portion of the plumes within a TI Zone. MCLs would still be in effect for groundwater potentially usable as a drinking water source and located outside the proposed TI Zone boundary.

This alternative would not reduce the mass of contaminants beyond the rate of natural attenuation processes, as augmented by local application of hot spot treatment when appropriate. Within the proposed TI Zone, compliance with certain chemical-specific ARARs is not expected to be achieved, even after decades or centuries, due to the complex fracture network and the long-term back-diffusion of PCE and other COCs out of the bedrock matrix and into migrating groundwater. Because the rate of PCE mass removal would be limited by the rate that PCE is made available by back-diffusion from rock pores into migrating groundwater, the time frame of Alternative 3 would be similar to that of active extraction approach of Alternative 2, since the effectiveness of active extraction is also limited by the rate of back-diffusion.

As discussed above in Section 1.6.2 and in the Updated FFS, modeled concentrations of chlorinated VOCs in underlying bedrock at the location of downgradient surface water bodies

such as Rock Creek, the Lower Rock Creek Wetlands, and the Mississippi River were projected at steady-state conditions to be compliant with identified surface water quality criteria. Based on modeling, this alternative could meet chemical-specific ARARs for ecological receptors.

4.2.4 Cost and Estimated Time Frame

As shown in Table 4-1, the estimated total present worth for Alternative 3 is \$ 18,600,000.

It is expected that aquifer restoration under this alternative will require decades or centuries due to the long-term back-diffusion of residual PCE from the aquifer matrix.

4.2.5 Key Performance Limitations

- A large spatial area and aquifer volume of bedrock will remain impacted by residual VOC mass, which will exist as a long-term source of dissolved VOCs to groundwater.
- Biodegradation removes only dissolved-phase mass, because VOCs are bioavailable only in the dissolved form.
- Most contaminant mass at the Site is likely found in rock pores or dead-end fractures, and will back-diffuse into migrating groundwater at a limited rate.
- There is limited evidence of biodegradation of PCE in the East Region of the Site.

SECTION 5

TECHNICAL IMPRACTICABILITY WAIVER REQUEST

Based on the information presented in this TI Evaluation Report, FFFS, and Updated FFS, a TI waiver is appropriate for the Site. The presence of DNAPL in fractured carbonate bedrock will act as a continuing long-term source of chemical mass to groundwater as PCE back-diffuses from the rock matrix. These characteristics result in groundwater restoration being technically impracticable from an engineering perspective.

The following discussion addresses the required TI Evaluation components described in Section 4.3 TI Evaluation Components of the TI Waiver Guidance (EPA, 1993).

5.1 ARARs FOR WHICH TI DETERMINATION IS REQUESTED

The chemical-specific ARARs requested to be waived within the proposed TI Zone are for the identified chemical-specific groundwater cleanup goals listed in Table 1-2. The values in Table 1-2 represent standards set forth in the ESD as subsequently amended, along with proposed updates to bring the standards in line with current regulatory limits as discussed in the Updated FFS. These ARARs include the National Primary Drinking Water Standards established under the Safe Drinking Water Act (i.e., drinking water MCLs), the State of Iowa Action Levels, and risk-based values for the analytes listed in Table 1-2.

The site-specific data and evaluation in the TI Evaluation Report, FFFS, and Updated FFS support the determination that, within the proposed TI Zone, it is technically impracticable from an engineering perspective to achieve the groundwater cleanup goal concentrations listed in Table 1-2 within a reasonable time frame.

The chemical constituents for which a TI Waiver of chemical-specific ARARs is requested are PCE, which has been observed at concentrations greater than the Proposed Groundwater Cleanup Goal listed in Table 1-2, along with known daughter products resulting from the biodegradation of PCE. These daughter products include TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride. The migration in groundwater of benzene, which resulted from historic DAC releases, is anticipated to be similar to that of dissolved-phase PCE; therefore, benzene is also included in this TI Waiver request. Additional background information on other analytes compiled in Table 1-2 is provided in the table footnotes.

5.2 PROPOSED EXTENT OF TI ZONE

The horizontal area over which the TI determination is requested (the TI Zone) is illustrated in Figure 5-1. The vertical extent of the TI Zone would be from the shallowest occurrence of groundwater down to the top of the dense shale Maquoketa Formation confining unit. Since PCE is the most widespread of the analytes for which a TI Waiver is requested; therefore, the TI Zone is based on PCE observed in groundwater. The PCE daughter products and benzene are generally detected within the PCE-impacted areas, such that this TI Zone is also appropriate for

all of the analytes described in Section 5.1. The extent of the proposed TI Zone encompasses areas of potential residual DNAPL and areas of fractured bedrock that are known to be or that may become impacted. As discussed in this document, it is technically impracticable to achieve the designated chemical-specific ARARs within the TI Zone.

The western TI Zone boundary is close to the currently-designated boundary line of the Site, including the impacted portion of the Western Unnamed Tributary watershed. The eastern boundary encompasses the Eastern Unnamed Tributary, while excluding areas not known to contain elevated PCE concentrations. These boundaries were drawn to reflect a 5 µg/L PCE concentration contour based on the most recent available groundwater monitoring data.

The northern (upgradient) boundary was drawn based on the inferred PCE plume boundary, at a concentration of 5 µg/L, with 1992 PCE data used in areas where more recent data were not available.

The southern (downgradient) TI Zone boundary was drawn based on the existing 5 µg/L PCE plume boundary, with an extension southward to allow for expected matrix diffusion.

5.3 SITE CONCEPTUAL MODEL

The site conceptual model, described in Section 2, is further detailed in the FFFS and Updated FFS.

5.4 RESTORATION POTENTIAL

The restoration potential for this site is limited. PCE will continue to back-diffuse out of bedrock pores, serving as a long-term source of PCE to groundwater. There is no technically practicable way to capture or treat the entire groundwater plume over the extensive volume of chemically-impacted fractured bedrock at the Site.

5.4.1 Addressing Source Areas

To the extent practicable, source areas have been addressed at the Site. For the West Region of the Site, the source area is the Chemplex Landfill, which was addressed by removal of VOCs from the landfilled material, followed by VOC mass destruction using catalytic oxidation, under OU-2. Other OU-2 remedial actions are discussed in Section 3.2. Extensive VOC mass was also removed during nearly 14 years of operation of the Chemplex pump-and-treat system.

For the East Region of the Site, a specific source area has not been identified, despite extensive investigation. The source is distinct from the Chemplex Landfill source and is likely much smaller due to the smaller amount of PCE found in the East Region.

5.4.2 Analysis of Remedial Actions

A discussion of the performance of remedial actions is contained in Section 3. Section 2.4 further discusses the difficulty of aquifer restoration in a fractured, DNAPL-impacted environment, highlighting the role of back-diffusion from the aquifer matrix in Section 2.4.4.

5.4.3 Predictive Analyses of Time Frames to Achieve Cleanup Levels

Given the fractured bedrock conditions and release of DNAPL at the Site, followed by migration of DNAPL into fractures and rock pores and subsequent long-term back-diffusion, it is not possible to accurately estimate this time frame. It is likely that any remedial action at the Site would take many decades or centuries to restore the aquifer to groundwater cleanup goals.

5.4.4 Demonstration That Other Technologies Are Not Appropriate

The difficulties of remediation in a fractured bedrock environment have been well demonstrated. A wide range of treatment options, including innovative technologies, were evaluated in Section 4.6 of the FFFS. None of the evaluated technologies are expected to be capable of restoring the aquifer to MCLs in a reasonable time frame.

This TI Evaluation Report, the FFFS, and the Updated FFS document that the current groundwater pump-and-treat remedy is not an effective remedial approach to protect human health and the environment at the Chemplex Site. In addition to an inability to completely and reliably capture migrating contamination, the groundwater pump-and-treat system appears to have 1) increased lateral migration by steepening horizontal gradients, 2) increased vertical migration by increasing naturally-downward gradients, particularly in the East Region, and 3) consequently decreased the intrinsic biodegradation potential by increasing groundwater velocity and introducing oxygenated groundwater from outside the plume that can suppress anaerobic, VOC-degrading bacteria.

5.5 COSTS OF REMEDY OPTIONS

The costs of remedy alternatives are summarized in Table 4-1. The recommended remedy, Alternative 3 – Enhanced Exposure Control has an estimated total present worth cost of \$18,600,000.

SECTION 6

SUMMARY AND CONCLUSIONS

Based on the site-specific data and evaluations presented in this TI Evaluation Report and in the FFFS and Updated FFS, ACC/GCC requests that EPA waive certain chemical-specific ARARs within the proposed TI Zone because it is technically impracticable from an engineering perspective to achieve these ARARs within the TI Zone. No identified or prospective remedial technology would be able to restore the affected aquifers within a reasonable time frame.

Several key factors present at the Site will prevent aquifer restoration within a reasonable time frame:

- PCE was released in the form of free-phase DNAPL and has reached fractured bedrock. Much or most of this mass has migrated into dead-end fractures and rock pores surrounding these fractures. Back-diffusion of PCE from these rock pores will be a long-term source of dissolved chemicals to migrating groundwater.
- The presence of residual chlorinated solvent impacts within a complex, interlocking fracture network over an extensive volume and depth within the Site's carbonate aquifers will not allow reliable and complete groundwater capture or chemical destruction or removal.
- Contaminant back-diffusion from the fractured bedrock matrix severely limits groundwater restoration.

The spatial area over which the proposed TI Zone extends is illustrated in Figure 5-1. The vertical extent of the TI Zone is from the shallowest occurrence of groundwater, within surficial Overburden soil, down to the top of the Maquoketa Formation, a dense, massive shale that is considered to be a regional aquiclude. Due to the presence of dispersed, residual source material in the form of impacted soil and dispersed VOC mass originally released in the form of DNAPL, at depths well below the water table and extending into fractured bedrock, it is technically impracticable to attain the designated chemical-specific ARARs within the TI Zone within a reasonable time frame.

In addition to the previously-accomplished source removal, ACC/GCC proposes a technically practicable alternative remedial strategy that incorporates 1) extension of the municipal water system to designated potentially downgradient residences, 2) institutional controls, 3) treatment of localized chemical "hot spots", and 4) expansion of the monitoring network to assess progress toward groundwater cleanup goals in the downgradient Site area. This alternative remedial strategy, described below, will be protective of human health and the environment:

- Extension of the municipal potable water system: The City of Camanche municipal water system has already been extended to designated residences located downgradient of the Site as part of the Performance Test of an

alternative remedy under the April 2008 SOAW (EPA, 2008). Most of these designated residences have now connected to the municipal water supply and had their private wells abandoned. The designated residences not currently connected to the extended waterline could be easily connected in the future if a potential risk were detected and confirmed by the expanded groundwater network.

- Institutional controls: Potential exposure to chemically-impacted groundwater will be controlled through a system of institutional controls. These controls include environmental covenants restricting land uses and potable water well construction in areas above the Maquoketa Shale downgradient of the Site. A City of Camanche ordinance prohibits new water wells in the downgradient residential area, requiring that new services be connected to the City water system.
- “Hot spot” treatment of elevated chemical concentrations: Localized PCE hot spots will be treated with a strong oxidant (such as permanganate) or supplemental electron donor (such as vegetable oil) to reduce the potential for chemical migration outside the TI Zone above groundwater cleanup goals when determined to be appropriate in consultation with EPA.
- Expanded groundwater and surface water monitoring network: The expanded groundwater network will continue to be monitored to evaluate groundwater concentration changes and plume migration.

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TABLES

TABLE 1-1

**KNOWN WATER WELLS
CHEMPLEX SITE, CLINTON, IOWA**

Reference Number in Figure 1-4	Well Owner/ID	Well Depth (feet bgs)	Screen or Open Interval (feet bgs)	Aquifer	Use
19402	Chemplex # 1	2,503	960 - 2,503	Cambrian-Ordovician	Commercial
19126	Chemplex # 3	2,571	935 - 2,571	Cambrian-Ordovician	Commercial
21285	Chemplex # 4	2,546	944 - 2,546	Cambrian-Ordovician	Commercial
18973	Chemplex # 6	2,529	Unknown	Cambrian-Ordovician	Commercial
Lyondell #7	Lyondell # 7	2,500	930-2,500	Cambrian-Ordovician	Commercial
13999	Hawkeye Chemical # 1	2,205	891 - 2,205	Cambrian-Ordovician	Commercial
13965	Hawkeye Chemical # 2	2,205	885 - 2,205	Cambrian-Ordovician	Commercial
14050	Hawkeye Chemical # 3	2,205	859 - 2,205	Cambrian-Ordovician	Commercial
23570	Walker	145	102 - 145	Silurian	Private
1	Hazel Foley	30	Unknown	Unknown	Private
14	Steve Bark	160	Unknown	Unknown	Private
18	John Thomas	Unknown	Unknown	Unknown	Private
19	Walter Blandixen (Decker)	60	Unknown	Unknown	Private
22	Laurence Todtz	150	Unknown	Unknown	Private
37	Larry Munck	Unknown	Unknown	Unknown	Private
38	Larry Munck	Unknown	Unknown	Unknown	Private
49	Unknown	Unknown	Unknown	Unknown	Private

Notes:

Source: May 9, 2003 Table from Clinton County Health Department (as determined from the Geologic Survey Bureau [GSB] website and provided file information).

Listing was further updated following abandonment of private residential wells along 9th Street and 31st Avenue as part of the water main extension project.

bgs = Below ground surface.

TABLE 1-2

**SUMMARY OF CURRENT AND PROPOSED GROUNDWATER CLEANUP GOALS
CHEMPLEX SITE, CLINTON, IOWA**

Compound	Current^a Groundwater Cleanup Goals (µg/L)	Proposed Groundwater Cleanup Goals (µg/L)	TI Waiver Requested (Yes/No)
Volatile Organic Compounds			
Benzene	1	5	Yes
1,2-Dichlorobenzene	600	600	No
1,1-Dichloroethene	7	7	Yes
1,2-Dichloroethene (sum of cis- and trans- isomers)	70	-- ^b	No ^b
cis-1,2-Dichloroethene	--	70	Yes
trans-1,2-Dichloroethene	--	100	Yes
Ethylbenzene	700	700	No
Methylene Chloride	5	5	No ^c
Styrene	100	100	No
1,1,1,2-Tetrachloroethane	0.2	-- ^d	No
Tetrachloroethene (PCE)	5	5	Yes
Toluene	2,000	1,000	No
1,1,1-Trichloroethane	200	200	No
Trichloroethene (TCE)	3	5	Yes
Vinyl Chloride	0.015	2	Yes
Xylenes	10,000	10,000	No
Polynuclear Aromatic Hydrocarbons			
Benzo(a)pyrene	0.2	0.2	No ^e
Naphthalene	20	1.4 ^f	No ^f
Metals			
Antimony	3	6	No
Arsenic	0.03	10	No ^g
Barium	2,000	2,000	No

Notes:

^a Current Groundwater Cleanup Goals are as shown in *Five Year Report for the Chemplex Site*, dated June 9, 1999, and prepared by the Environmental Protection Agency, Region VII (EPA).

^b The Consent Decree for the Chemplex First Operable Unit, dated September 1990, set forth a Groundwater Cleanup Standard of 70 micrograms per liter (µg/L) for total 1,2-Dichloroethene (Total 1,2-DCE) based on the then-current Health Advisory Level (HAL). This standard was established for the total of the cis and trans isomers because the analytical instruments at that time could not readily separate and report the two isomers individually. Because modern instruments can report the concentration of each isomer, and because both isomers have Federal Drinking Water Maximum Contaminant Levels (MCLs), ACC/GCC is proposing a Groundwater Cleanup Goal for each isomer that is equal to its MCL. A cleanup goal for Total 1,2-DCE is thus no longer needed.

TABLE 1-2

**SUMMARY OF CURRENT AND PROPOSED GROUNDWATER CLEANUP GOALS
CHEMPLEX SITE, CLINTON, IOWA**

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- ^c Methylene chloride has been sporadically detected in Site groundwater analyses. These detections of methylene chloride, a common laboratory contaminant, in Chemplex groundwater are generally believed to result from laboratory contamination in view of repeated detections of this analyte in trip and field blanks collected during Site sampling events. Methylene chloride will continue to be evaluated in the Chemplex groundwater monitoring network.
- ^d As described in Section 4.2 of the Updated Focused Feasibility Study, dated February 2012, ACC/GCC proposes the Cleanup Goal for this analyte be deleted. In recent groundwater sampling events, 1,1,2,2-tetrachloroethane was not detected above the current cleanup standard, and therefore does not appear to be a chemical of concern at this Site; thus, it is proposed that the cleanup standard be deleted and that this analyte be deleted from the list of chemicals of concern for the Chemplex Site.
- ^e Benzo(a)pyrene is a polynuclear aromatic hydrocarbon (PAH) associated with historic releases of debutanized aromatic concentrate (DAC), a byproduct of ethylene production. As PAHs such as benzo(a)pyrene are generally less mobile in groundwater compared with volatile organic compounds (VOCs), their distribution at the Chemplex Site is not as widespread as PCE and its daughter products. Benzo(a)pyrene has been found from time to time in groundwater downgradient of the DAC management area of the polyethylene plant.
- ^f Naphthalene is a PAH associated with historic releases of DAC and potentially with wastes disposed of in the Chemplex Landfill. The 1990 Consent Decree used the HAL for naphthalene, 20 µg/L, as a surrogate for establishment of cleanup standards for a number of non-carcinogenic PAHs. The Environmental Protection Agency (EPA) has not established an MCL for naphthalene. EPA has now determined that naphthalene may be a carcinogen, and has set a concentration of 1.4 µg/L, equivalent to a risk level of one-in-one hundred thousand (10⁻⁵), as a presumptive groundwater cleanup goal. For reference, the Iowa Statewide Standard for naphthalene in Protected Groundwater is 100 µg/L, and 700 µg/L in Non-Protected Groundwater. As PAHs such as naphthalene are generally less mobile in groundwater compared with VOCs, their distribution at the Chemplex Site is not as widespread as PCE and its daughter products. Naphthalene has been found from time to time at levels below 20 µg/L but above 1.4 µg/L in groundwater immediately downgradient of the DAC management area. Naphthalene has also been occasionally detected above 1.4 µg/L in the far downgradient area of the Chemplex groundwater monitoring network. Given this analyte's limited mobility and the lack of a discernible naphthalene plume emanating from the plant area, it is not believed these far downgradient detections result from past plant operations.
- ^g Arsenic has been detected at the Chemplex Site at concentrations greater than the Proposed Groundwater Cleanup Goal. However, high background levels of arsenic are typical in Iowa. The Chemplex site is not a confirmed source of metals, including arsenic. Arsenic and other metals are no longer routinely sampled in Site groundwater.

TABLE 3-1

MASS RECOVERY RATE IN GROUNDWATER
OPERABLE UNIT NUMBER 1
CHEMPLEX SITE, CLINTON, IOWA

Year	Volatile Organic Compounds (pounds per day)
1995	10.9
1996	10.9
1997	7.6
1998	6.6
1999	6.7
2000	7.8
2001	4.4
2002	4.5
2003	4.5
2004	3.7
2005	3.1
2006	2.2
2007	2.0
2008	2.1

Note:

Groundwater pump and treat system was placed in stand-by in September 2008.

TABLE 3-2

**MASS RECOVERY RATE (POUNDS/DAY) IN LANDFILL GAS
OPERABLE UNIT NUMBER 2
CHEMPLEX SITE, CLINTON, IOWA**

	1998	1999	2000	2001	2002	2003
Total Target VOCs	50.0	24.6	4.2	8.1	5.6	4.3
Total Non-Target VOCs	43.6	8.6	1.4	3.2	2.3	2.3
Total VOCs	93.6	33.1	5.5	11.4	7.9	6.6

Note:

VOCs = Volatile organic compounds.

TABLE 4-1

**COMPARISON OF GROUNDWATER ALTERNATIVE COSTS AND TIME FRAMES
CHEMPLEX SITE, CLINTON, IOWA**

Alternative	Cost	Estimated Restoration Time Frame
1 - No Action	\$1,900,000	Greater than 100 Years
2 - Current Pump and Treat	\$27,900,000	Greater than 100 Years
3 - Enhanced Exposure Control	\$18,600,000	Greater than 100 Years

Notes:

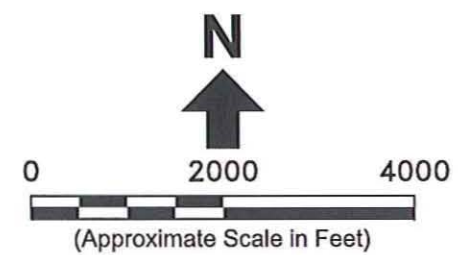
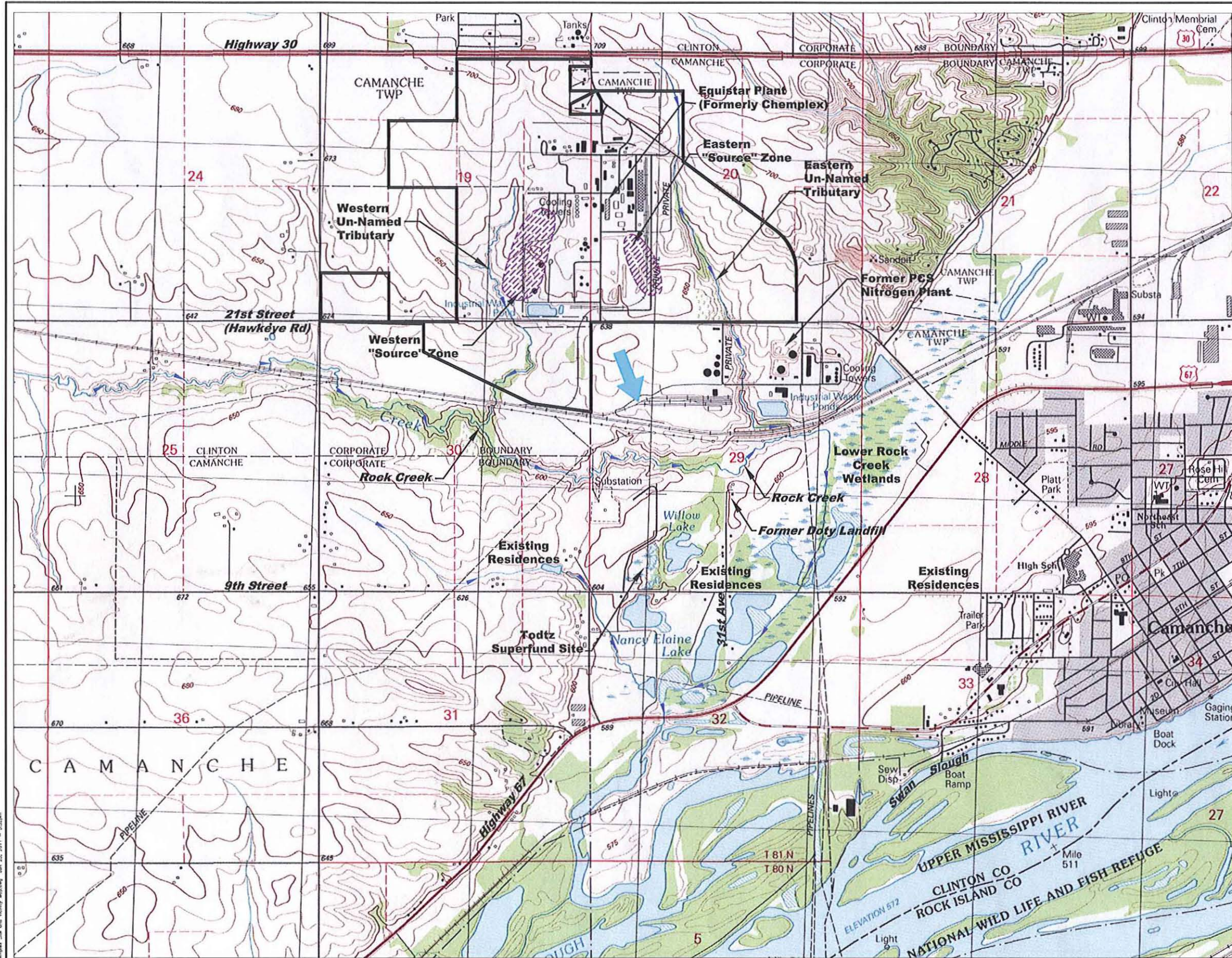
Cost breakdown for Alternative 1 is presented in the Final Focused Feasibility Study (FFFS).

Cost breakdowns for Alternatives 2 and 3 are presented in the Updated Focused Feasibility Study (FFS).

FIGURES



MWH

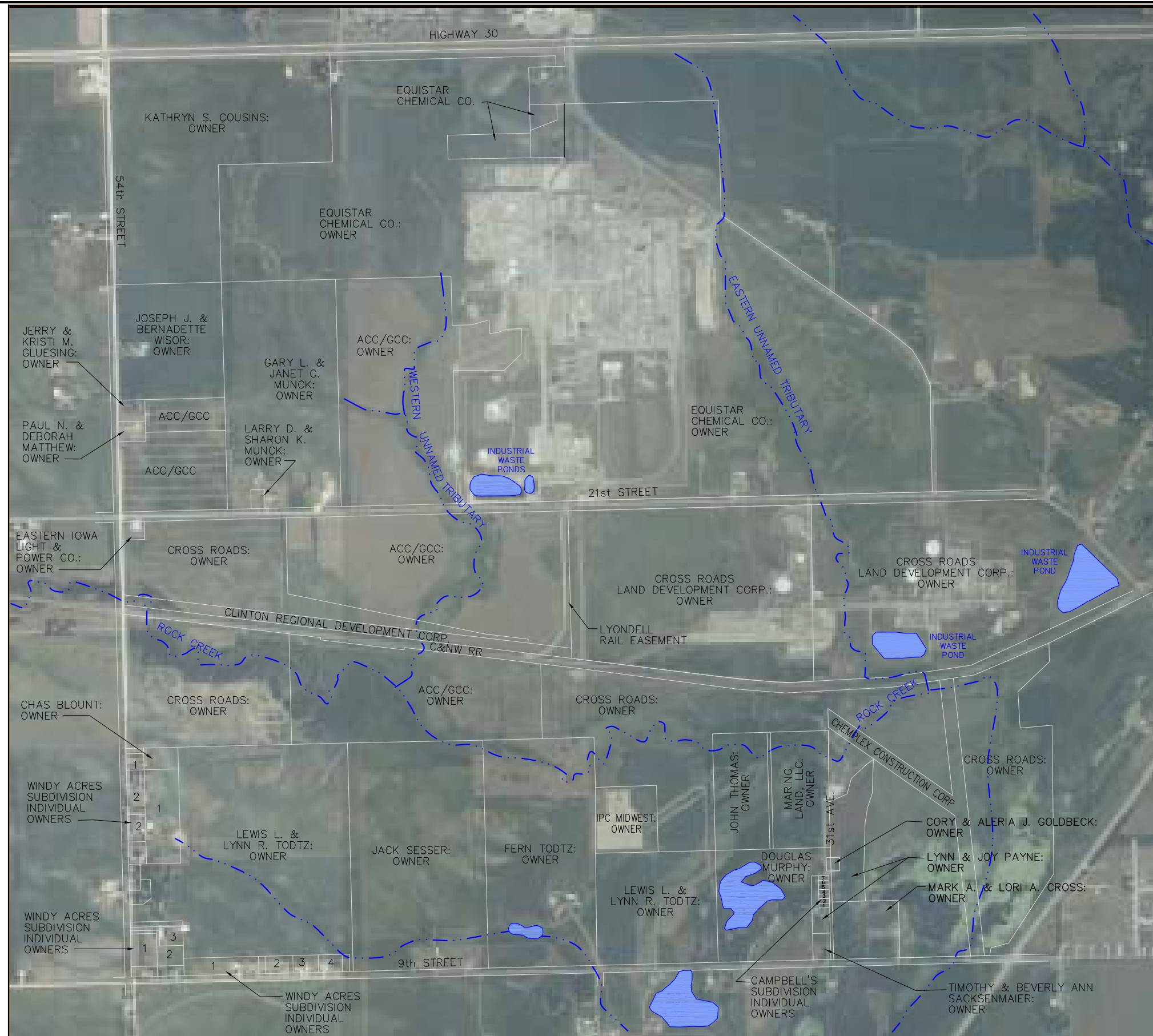


- Legend:**
- Approximate Property Boundary (Lyondell and ACC/GCC)
 - Assumed General Groundwater Gradient Direction
 - Creek Flow Direction
 - Estimated Source Zone

- Notes:**
1. All locations are approximate.
 2. Basemap source: USGS 7.5 minute series topographic map, Camanche Quadrangle, Iowa-Illinois, 1991.

Map Source: Erler and Kalinowski, Inc., June 2011

	DESIGNED BY	EQ	06/11		MANAGING OFFICE	DES MOINES, IOWA	
	DRAWN BY	NORA DAY	06/11		PROJECT	CHEMPLX CLINTON, IOWA	
	CHECKED BY	MIKE ALOWITZ	06/11		TITLE	CHEMPLX SITE AND VICINITY MAP	
	APPROVED BY	MIKE ALOWITZ	06/11				
	PROJECT MANAGER	MIKE ALOWITZ	06/11				
	CLIENT REFERENCE NO.	1010756 0101					
							FIGURE 1-1



NOTES:

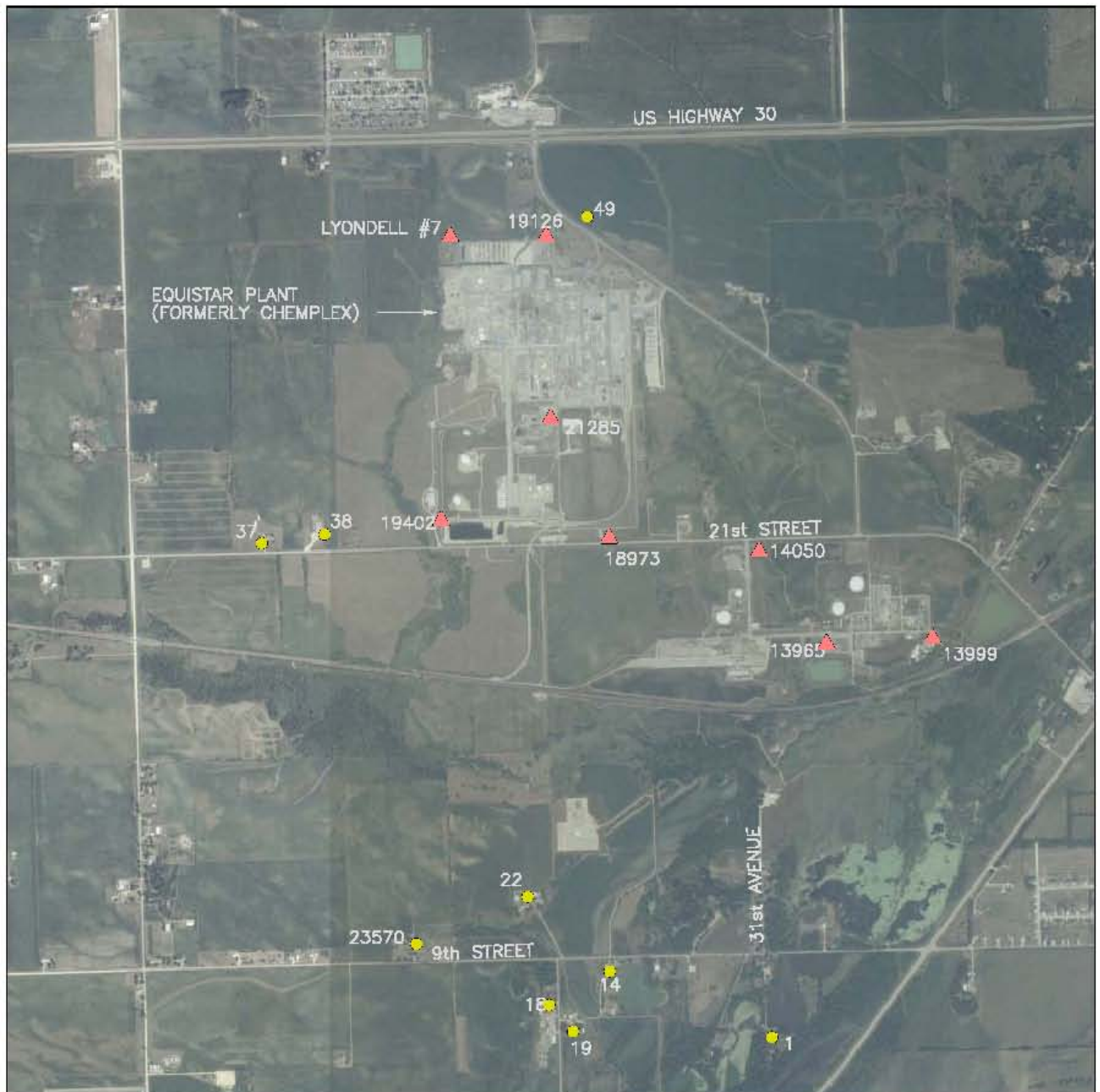
1. OWNERSHIP SHOWN BASED ON CITY AND COUNTY OWNERSHIP MAPS AS OF OCTOBER 25, 2006, AND MORE RECENT SALES DATA. OWNERSHIP IS SUBJECT TO CHANGE. FIGURE HAS BEEN UPDATED TO SHOW CRDC PURCHASE AND CROSS ROADS PURCHASES IN 2009.
2. PROPERTY LINES SHOWN ARE FOR THE PURPOSE OF SHOWING BASIC DIVISION OF OWNERSHIP AND DO NOT REPRESENT AN ACTUAL SURVEY. THIS MAPPING SHOULD NEVER BE RELIED UPON TO ESTABLISH THE LOCATION OF PROPERTY LINES OR THE LOCATION OF ANY OTHER FEATURE IN RELATION TO A PROPERTY LINE.
3. AERIAL MAP SOURCE:
IOWA GEOGRAPHIC MAP SERVER
2005 ORTHOPHOTOS — USDA
DATE OF PHOTOGRAPHY: 8-2-2005

DESIGNED BY	MIKE ALLOWITZ	06/11
DRAWN BY	NORA DAY	06/11
CHECKED BY	MIKE ALLOWITZ	06/11
APPROVED BY	MIKE ALLOWITZ	06/11
PROJECT MANAGER	MIKE ALLOWITZ	06/11
CLIENT APPROVAL	.	
CLIENT REFERENCE NO.	1010756.0101	



PROJECT LOCATION	DES MOINES, IOWA
PROJECT	CHEMPLEX CLINTON, IOWA
TITLE	PRIMARY PROPERTY OWNERS MAP

FIGURE	1-2
REVISION	.
FILE NAME	.



LEGEND:

- WATER WELL OPEN ABOVE THE MAQUOKETA FORMATION
- ▲ WATER WELL OPEN BELOW THE MAQUOKETA FORMATION

AERIAL MAP SOURCE:

IOWA GEOGRAPHIC MAP SERVER
2005 ORTHOPHOTOS — USDA
DATE OF PHOTOGRAPHY: 8-2-2005

NOTE:

WELLS KNOWN TO EXIST ARE SHOWN. MANY PRIVATE WELLS WERE ABANDONED AND RESIDENCES CONNECTED TO THE CITY OF CAMANCHE MUNICIPAL WATER SYSTEM IN 2010.



I:\Projects\Chemplex\Map\Map.dwg 11/11/2011 11:11:11 AM

DESIGNED BY	MIKE ALDITZ	08/11
DRAWN BY	NORA DAY	08/11
CHECKED BY	MIKE ALDITZ	08/11
APPROVED BY	MIKE ALDITZ	08/11
PROJECT MANAGER	MIKE ALDITZ	08/11
CLIENT APPROVAL		
CLIENT REFERENCE NO.	80107810001	

0 1000 2000
SCALE IN FEET

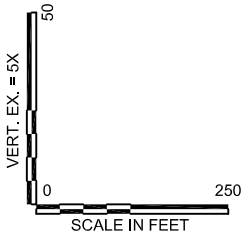
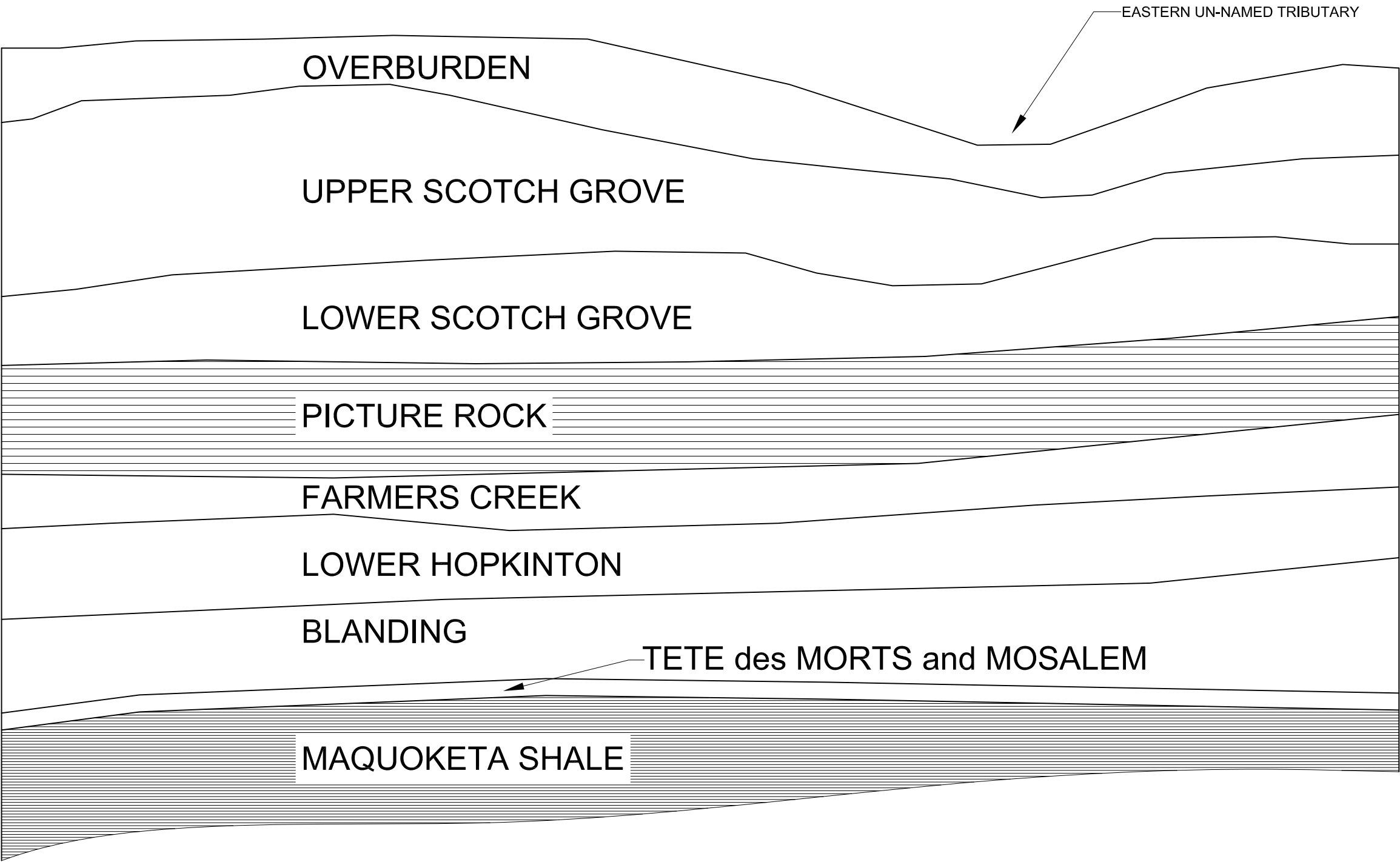
MANAGING OFFICE	DES MOINES, IOWA
PROJECT	CHEMPLEX CLINTON, IOWA
TITLE	WATER WELL LOCATIONS



FIGURE
1-3

WEST

EAST



Source: Adaped from Erler and Kalinowski, Inc.,
November 2006

DESIGNED BY	EKI	06/11	MANAGING OFFICE	DES MOINES, IOWA
DRAWN BY	NORA DAY	06/11	PROJECT	CHEMPLEX CLINTON, IOWA
CHECKED BY	MIKE ALOWITZ	06/11		
APPROVED BY	MIKE ALOWITZ	06/11		
PROJECT MANAGER	MIKE ALOWITZ	06/11	TITLE	BEDROCK STRATIGRAPHY
CLIENT REFERENCE NO.	1010756.0101			


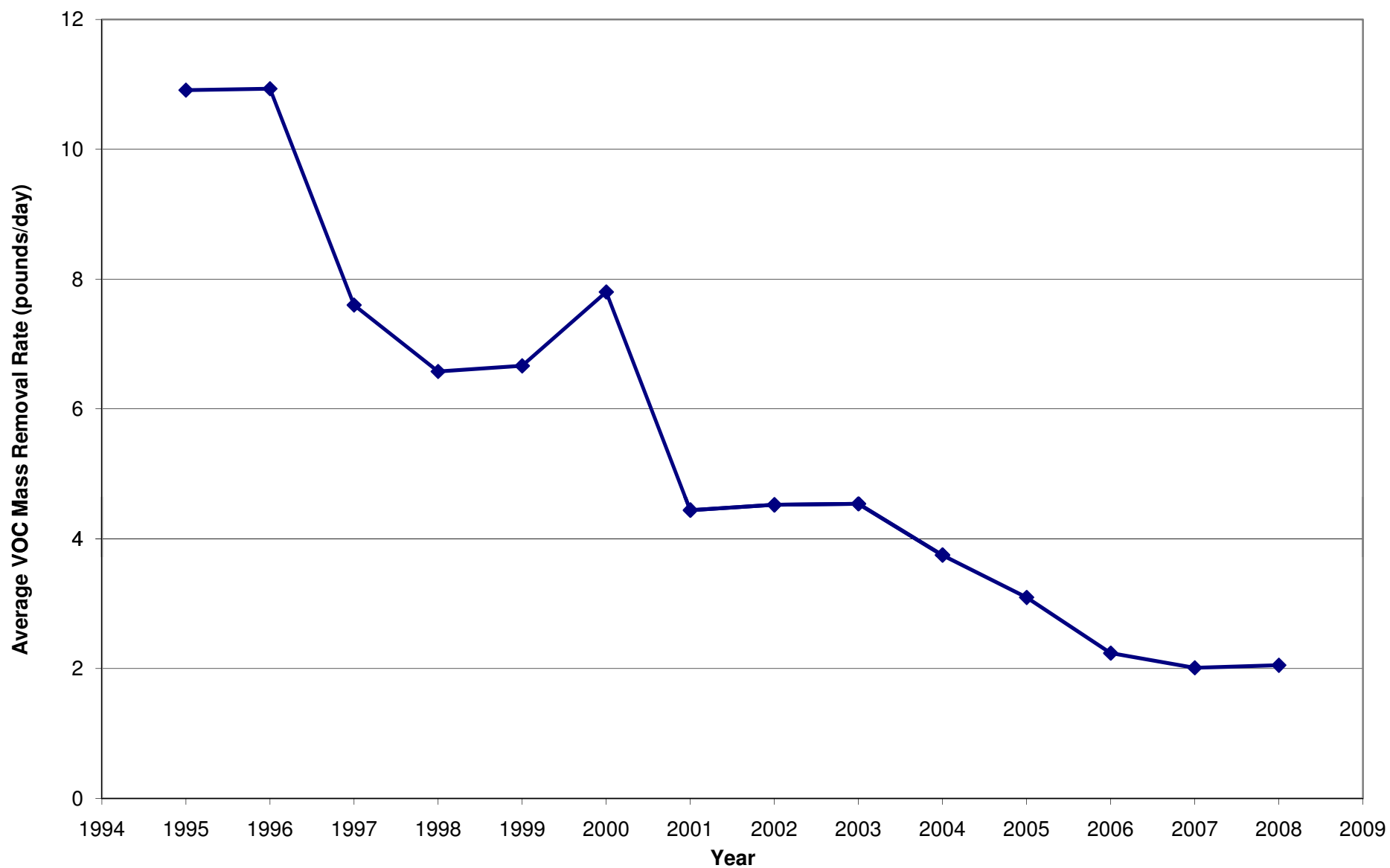


FIGURE
2-1



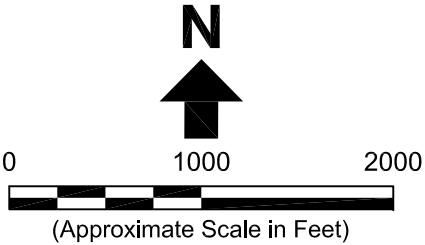
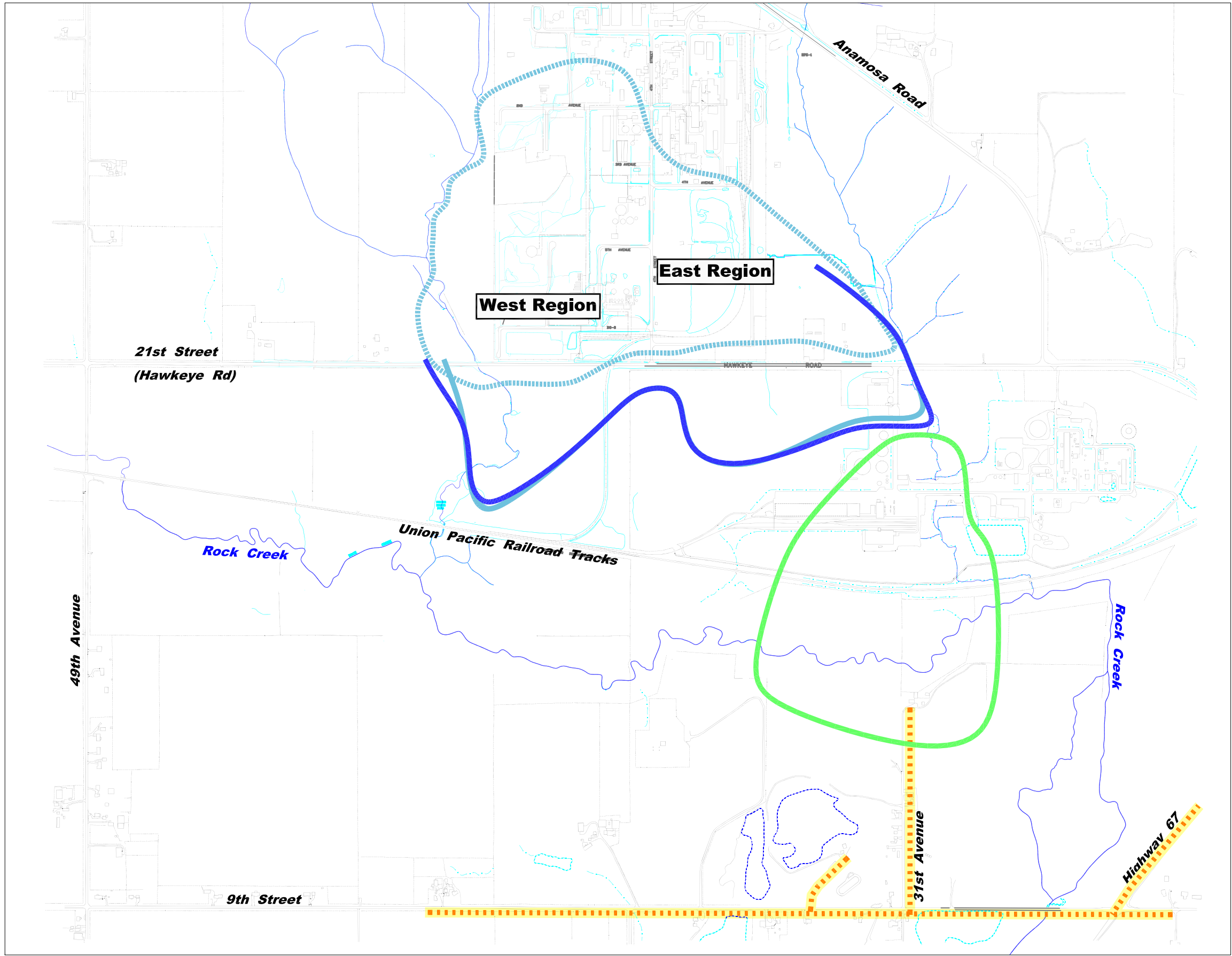
DESIGNED BY	MIKE ALOWITZ	06/11
DRAWN BY	NORA DAY	06/11
CHECKED BY	JEFF COON	06/11
APPROVED BY	MIKE ALOWITZ	06/11
PROJECT MANAGER	MIKE ALOWITZ	06/11
CLIENT APPROVAL		
REFERENCE NO.	1010756.0101	

PROJECT LOCATION	DES MOINES, IOWA
PROJECT	CHEMPLEX CLINTON, IOWA
TITLE	MASS RECOVERY RATE IN GROUNDWATER OPERABLE UNIT NUMBER 1



FIGURE

3-1






Legend:

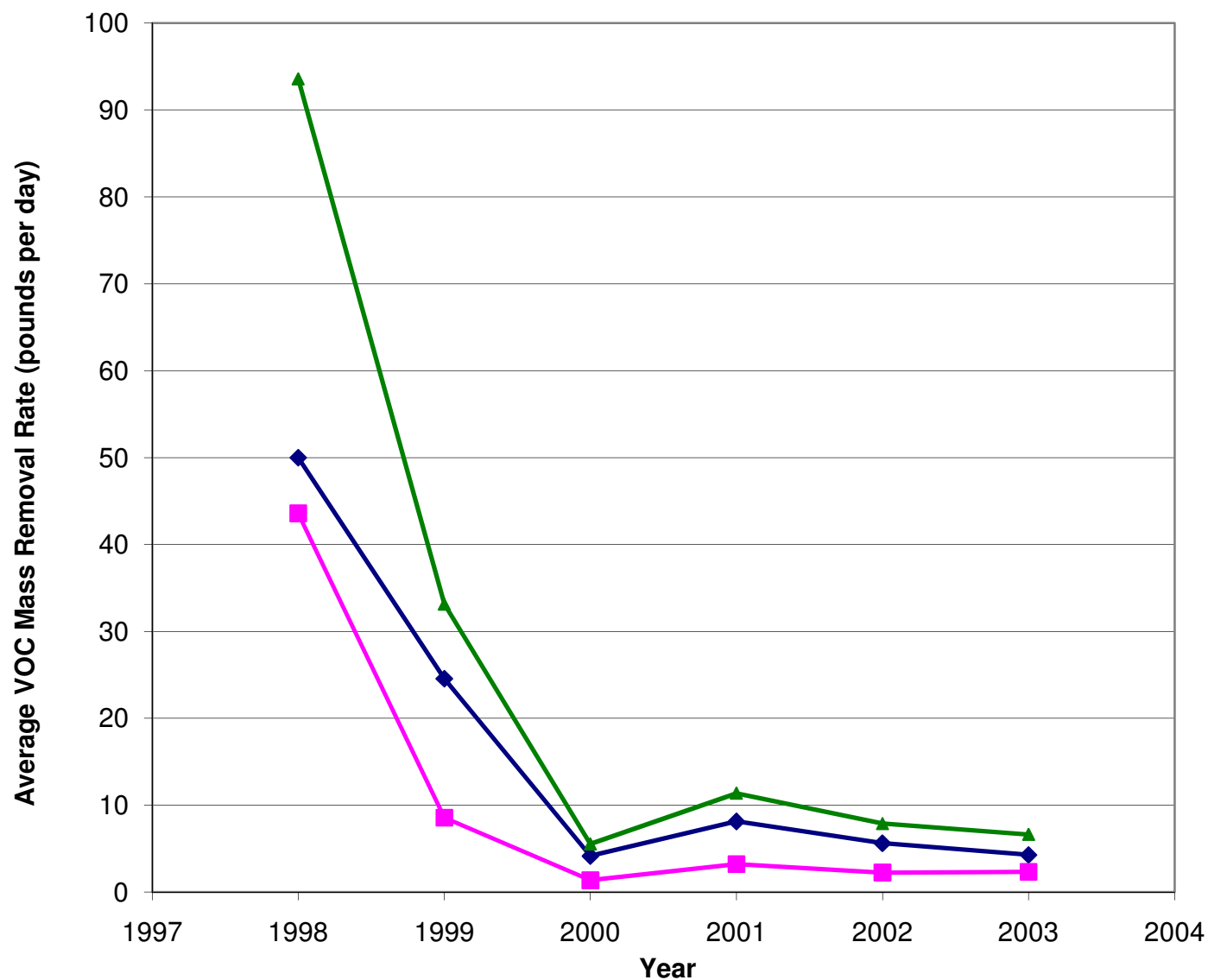
- 1992 PCE Groundwater Plume Contour (10 ug/L)
- 2008 PCE Groundwater Plume Contour (5 ug/L)
- 2011 PCE Groundwater Plume Contour (5 ug/L)
- 2008 Nitrate in Groundwater Plume Contour (10 mg/L)
- Municipal Water System Extension

Notes:

- The 2008 PCE concentration contour is based on data from April 2008, while the 2011 PCE concentration contour is based on data from November 2011.
- The 1992 tetrachloroethene ("PCE") concentration contour was based on concentrations reported in Montgomery Watson's *First Operable Unit Remedial Investigation Report*, dated August 1992.
- The 2008 nitrate concentration contour was as reported in MACTECs *Report of Annual Monitoring and Remediation for 2008, PCS Nitrogen, Clinton, Iowa*, dated 25 March 2009.

P:\CD\Clinton\Figure 3-2 - PCE Contour Mapping June 12, 2012 - 8/22/09

	DESIGNED BY	EKI	06/11	 SCALE IN FEET	MANAGING OFFICE	DES MOINES, IOWA	
	DRAWN BY	NORA DAY	06/11		PROJECT	CHEMPLEX CLINTON, IOWA	
	CHECKED BY	MIKE ALOWITZ	06/11		TITLE	SUMMARY OF PCE PLUME IN GROUNDWATER OVER TIME	
	APPROVED BY	MIKE ALOWITZ	06/11				FIGURE 3-2
	PROJECT MANAGER	MIKE ALOWITZ	06/11				
	MWH REFERENCE NO.	1010756.0101					



DESIGNED BY	MIKE ALOWITZ	06/11
DRAWN BY	NORA DAY	06/11
CHECKED BY	JEFF COON	06/11
APPROVED BY	MIKE ALOWITZ	06/11
PROJECT MANAGER	MIKE ALOWITZ	06/11
CLIENT APPROVAL		
REFERENCE NO.	1010756.0101	

PROJECT LOCATION	DES MOINES, IOWA
PROJECT	CHEMPLEX CLINTON, IOWA
TITLE	MASS RECOVERY RATE IN LANDFILL GAS OPERABLE UNIT NUMBER 2



FIGURE

3-3

